IN THE UNITED STATES DISTRICT COURT
FOR THE DISTRICT OF DELAWARE

ALCOA, INC., Plaintiff,	
v.	C.A. No. 06-383-SLR
ALCAN INC., a Canadian corporation, ALCAN CORP., a Texas corporation, ALCAN CORP., a Delaware corporation, PECHINEY, S.A., a French corporation, ALCAN RHENALU, a French corporation, ALCAN PECHINEY CORP., a Texas corporation, PECHINEY METALS, LLC, a Delaware limited liability company, ALCAN ROLLED PRODUCTS – RAVENSWOOD, LLC, a Delaware limited liability company, Defendants.	

APPENDIX TO DEFENDANTS' MEMORANDUM OF LAW IN SUPPORT OF THEIR MOTION TO DISMISS FOR FAILURE TO STATE A CLAIM UPON WHICH RELIEF CAN BE GRANTED

(VOLUME 1 OF 2)

ASHBY & GEDDES
Steven J. Balick (I.D. #2114)
John G. Day (I.D. #2403)
Tiffany Geyer Lydon (I.D. #3950)
222 Delaware Avenue, 17th Floor
P.O. Box 1150
Wilmington, DE 19899
sbalick@ashby-geddes.com
jday@ashby-geddes.com
tlydon@ashby-geddes.com

Counsel for Defendants

Of Counsel:

Steven R. Trybus
Donald R. Cassling
Shelley Smith
Patrick L. Patras
JENNER & BLOCK LLP
One IBM Plaza
Chicago, IL 60611

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TABLE OF CONTENTS

Exhibit 1

ABANDONED

ABANDONED

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07/572625		

SERIAL NUMBER	FILING DATE	CLASS	SUBCLASS	GROUP ART UNIT	EXAMINER
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APPLICANT

EDWARD L. COLVIN, PITTSBURGH, PA; JOCELYN I. PETIT, NEW KENSINGTON, PA; ROBERT W. WESTERLUND, BETTENDORF, IA.

KOEHLER

CONTINUING DATA*******************

VERIFIED

RDK

FOREIGN/PCT APPLICATIONS**********

VERIFIED

RDK

NOTE - DISCLAIMER
The term of this patent
subsequent to ____________
has been disclaimed

Foreign priority claimed 35 USC 119 conditions met	☐ yes ☒ no ☐ yes ☒ no	AS FILED	STATE OR COUNTRY	SHEETS DRWGS	TOTAL CLAIMS	INDEP CLAIMS	FILING FEE RECEIVED	ATTORNEY'S DOCKET NO.
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ADDRESS

ANDREW ALEXANDER
ALUMINUM COMPANY OF AMERICA
ALCOA CENTER, PA 15069

TITLE

DAMAGE TOLERANT ALUMINUM ALLOY CLAD SHEET FOR AIRCRAFT SKIN

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Sheets Drwg.	Figs. Drwg.	Print Fig.
4	4	1

DISCLAIMER LABEL

SERIAL NO.	FILING DATE
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DO NOT DESTROY

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Abstract of the Disclosure

Disclosed is a method of producing a sheet product having improved levels of toughness and fatigue crack growth resistance while maintaining high strength, comprising providing a body of an aluminum base alloy containing 4.0 to 4.5 wt.% Cu, 1.2 to 1.5 wt.% Mg, 0.4 to 0.6 wt.% Mn, 0.12 wt.% max. Fe, 0.05 wt.% max. Si, the remainder aluminum, incidental elements and impurities and heating a body of the alloy to above 910°F to dissolve soluble constituents. Thereafter, the body is hot rolled in the range of about 600 to 900°F, solution heat treated for a time of less than about 15 minutes at a solution heat treating temperature, and rapidly cooled and naturally aged to provide a sheet product with improved levels of fatigue crack growth resistance while maintaining high strength.

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DAMAGE TOLERANT ALUMINUM ALLOY CLAD SHEET FOR AIRCRAFT SKIN

Background of the Invention

This invention relates to aluminum alloys suitable for use in aircraft applications and more particularly, it relates to an improved aluminum alloy and processing therefor having improved resistance to fatigue crack growth and fracture toughness and suited to use as aircraft skin.

The design of commercial aircraft requires different sets of properties for different types of structures on the airplane. In many parts, resistance to crack propagation either in the form of fracture toughness or fatigue crack growth is essential. Therefore, many significant benefits can be realized by improving fracture toughness and fatigue crack propagation.

A new material with improved toughness, for example, will have a higher level of damage tolerance. On the aircraft, this translates to improved safety for passengers and crew and weight savings in the structure which allows for improved fuel economy, longer flight range, greater payload capacity or a combination of these.

Cyclic loading occurs on a commercial jet airplane during the take off/landing when the interior of the airplane is pressurized. Typically, airplanes may see up to 100,000 pressurization cycles during their normal service lifetime. Thus, it will be noted that great benefit is derived from improved fracture toughness and resistance to fatigue crack growth, both of which are related to cyclic loading.

U.S. Patent 4,336,075 discloses the use of AA2000 type aluminum alloy for aircraft wings.

The present invention provides aluminum base alloy sheet products and a method of fabricating sheet products from a body of the alloy. Further, the invention provides aluminum alloy sheet products suitable for aircraft applications such as wing skins and aircraft fuselage panels, which sheets are clad with a corrosion protecting outer layer.

Summary of the Invention

A principal object of the invention is to provide an aluminum alloy and sheet product formed therefrom, the sheet product having improved fracture toughness and resistance to fatigue crack growth while maintaining high strength properties and corrosion resistance.

A further object of the present invention is to provide aluminum alloy sheet products having improved fracture toughness and resistance to fatigue crack growth for aircraft panels.

Yet a further object of the present invention is to provide aluminum alloy sheet products and a process for producing the sheet products so as to provide improved fracture toughness and increased resistance to fatigue crack growth while still maintaining high levels of strength.

Still a further object of the invention is to provide a method for processing an aluminum alloy into clad sheet products having improved resistance to fatigue crack growth while maintaining high strength properties and corrosion resistance.

And still a further object is to provide an Al-Cu-Mg-Mn

clad sheet product for use as aircraft panels such as wing or fuselage skins having improved resistance to fatigue crack growth while maintaining high strength levels and improved fracture toughness.

These and other objects will become apparent from a reading of the specification and claims and an inspection of the claims appended hereto.

In accordance with these object, there is provided a method of producing a sheet product having improved levels of toughness and fatigue crack growth resistance while maintaining high strength, the method comprising providing a body of an aluminum base alloy containing 4.15 to 4.5 wt.% Cu, 1.2 to 1.45 wt.% Mg, 0.4 to 0.7 wt.% Mn, 0.1 wt.% max. Fe, 0.1 wt.% max. Si, the remainder aluminum, incidental elements and impurities. The method further comprises heating a body of the alloy to above 900°F to dissolve soluble constituents. Thereafter, the body is hot rolled in the range of about 600 to 900°F, solution heat treated for a time of less than about 15 minutes, for example, at the solution heat treating temperature, then rapidly cooled and naturally aged to provide a sheet product with improved levels of fatigue crack growth resistance and fracture toughness while maintaining high strength levels.

Brief Description of the Drawings

Figure 1 shows fracture toughness plotted against yield strength of improved material processed in accordance with the invention.

Figure 2 is a graph showing fatigue crack growth rate

plotted against crack length for Aluminum Association alloy 2024 in the solution heat treated, cold worked and naturally aged T3 temper (AA2024-T3) and the improved product in accordance with the invention.

Figure 3 is a differential calorimetry curve of 2024-T3.

Figure 4 is a differential calorimetry curve of an aluminum alloy product in accordance with the invention.

Detailed Description of the Preferred Embodiments

As noted, the alloy of the present invention comprises 4.0 to 4.5 wt.% Cu, 1.2 to 1.5 wt.% Mg, 0.4 to 0.7 wt.% Mn, 0.02 to 0.5 wt.% Fe, 0.001 to 0.5 wt.% Si, the balance aluminum, incidental elements and impurities. Impurities are preferably limited to 0.05% each and the combination of impurities preferably should not exceed 0.15%. The sum total of incidental elements and impurities preferably does not exceed 0.45%.

A preferred alloy would contain, 4.1 to 4.4 wt.% Cu, 1.2 to 1.45 wt.% Mg, 0.4 to 0.6 wt.% Mn, 0.1 wt.% max. Fe, 0.1 wt.% max. Si, the balance aluminum, incidental elements and impurities. Elements such as Zn preferably have a maximum of 0.2 wt.% and Cr 0.2 wt.% and 0.5 wt.% Zr, with a range for Zr being 0.05 to 0.25 wt.%, if it desired to make an unrecrystallized product. By unrecrystallized is meant that no more than 20 vol.% of the product is recrystallized. A typical alloy composition would contain about 4.25 wt.% Cu, 1.35 wt.% Mg, 0.5 wt.% Mn, 0.12 wt.% max. Fe and 0.1 wt.% max. Si with Fe plus Si not totaling more than 0.20 and preferbly not more than 0.15.

Mn contributes to or aids in grain size control during

operations that cause the metal to recrystallize. Very large grains are detrimental to properties such as fracture toughness, formability and corrosion resistance.

Fe and Si levels are kept low to limit formation of the constituent phases Al_7Cu_2Fe and Mg_2Si which are detrimental to fracture toughness and fatigue crack growth resistance. These phases have low solubility in Al-alloy and once formed cannot be eliminated by thermal treatments. Formation of Al_7Cu_2Fe and Mg_2Si phases can also lower the strength of the product because their formation reduces the amount of Cu and Mg available to form strengthening precipitates. Constituents such as Al_7Cu_2Fe and Mg_2Si are particularly important to avoid because they cannot be dissolved; thus, iron is kept to a very low level to avoid such constituents. That is, a decrease in Fe and Si increases toughness and resistance to fatigue crack growth. Thus, in the present invention, it is preferred to control Fe to below 0.10 wt.% and Si below 0.10 wt.%.

Cu and Mg must be carefully controlled to maintain good strength while providing the benefits in toughness and fatigue. The Cu and Mg levels must be low enough to allow for dissolution of the slightly soluble Al_2CuMg and Al_2Cu constituent phases during high temperature processing yet high enough to maximize the amount of free Cu and Mg available to form the strengthening precipitate phases. This leaves a very narrow range of Cu and Mg compositions which will produce the desired properties in the final product.

The following equations may be used to estimate the

"free Cu" and "free Mg"; that is, the amount of Cu and Mg that are available to form strengthening phases.

$$Cu_{Free}=Cu_{Total}-2.28Fe-0.74(Mn-0.2)$$

$$Mg_{Free}=Mg_{Total}-1.73(Si-0.05)$$

As well as providing the alloy product with controlled amounts of alloying elements as described herein, it is preferred that the alloy be prepared according to specific method steps in order to provide the most desirable characteristics of both strength, fracture toughness, corrosion resistance and resistance to fatigue crack growth as required, for example, for use as aircraft skins or panels. The alloy as described herein can be provided as an ingot or slab for fabrication into a suitable wrought product by casting techniques currently employed in the art for cast products with continuous casting being preferred. Slabs resulting from belt casters or roll casters also may be used.

In a broader aspect of the invention, the alloy can comprise 3.8 to 4.5 wt.% Cu, 1.2 to 1.85 wt.% Mg, 0.3 to 0.78 wt.% Mn, 0.5 wt.% max. Fe, 0.5 wt.% Si, the balance aluminum, incidental elements and impurities.

The ingot or slab of the alloy of the invention may be provided with a cladding and then processed in accordance with the invention. Such clad products utilize a core of the aluminum base alloy of the invention and a cladding of higher purity alloy which corrosion protects the core. The cladding includes essentially unalloyed aluminum or aluminum containing not more than 0.1 or 1% of all other elements. However, Zn can be present

as in AA7072, for example. Thus, the cladding on the core may be selected from Aluminum Association alloys 1100, 1200, 1230, 1135, 1235, 1435, 1145, 1345, 1250, 1350, 1170, 1175, 1180, 1185, 1285, 1188, 1199 or 7072.

The alloy stock may be homogenized prior to hot working or it may be heated and directly hot rolled. If homogenization is used, it may be carried out at a metal temperature in the range of 910 or 920°F to 960 or 1000°F for a period of time of at least 1 hour to dissolve soluble elements and to homogenize the internal structure of the metal. A preferred time period is about 4 hours or more in the homogenization temperature range. Normally, the soak time at the homogenizing temperature does not have to extend for more than 8 hours, however, longer times are not normally detrimental. 4 to 6 hours at the homogenization temperature has been found to be quite suitable. A typical homogenization temperature is 920°F.

For purposes of the present invention, it is preferred to hot roll the clad ingot without homogenizing. Thus, the ingot is hot worked or hot rolled to provide an intermediate gauge product. Hot rolling is performed wherein the starting temperature for rolling is in the range of 600 to 900°F. When the use of the alloy is for aircraft wing skins or fuselage skins, for example, the hot rolling is performed to provide an intermediate product having a thickness of about 3 to 8 inches.

After hot rolling, the intermediate gauge product is subjected to a reheating step. It is this reheating step which is so important to the present invention, particularly with

respect to minimizing or avoiding soluble constituent or secondary phase particles and their adverse effect on fatigue crack growth resistance and fracture toughness. Thus, in the reheating step, the intermediate gauge product is heated to a temperature of at least 900 or 920°F, e.g., above the solvus temperature of secondary phase particles, to dissolve soluble constituents that remain from casting or may have precipitated during the hot rolling. Such constituent particles include Al_2CuMg, Al_2Cu, for example. The reheating has the effect of putting most of the Cu and Mg into solid solution. The heating can be in the range of 900 to 945°F with a preferred range being 900 or 910 to 930°F. For purposes of reheating, the intermediate gauge product can be held for about 1 to 40 hours when the metal is in the temperature range or above the solvus temperature for the soluble constituents. Preferably, times at metal temperature are in the range of 4 to 24 hours. It is important that the reheat is carefully controlled within the parameters set forth. If the reheating operation is lower than 900°F, for example, 850°F, this can leave large volumes of coarse undissolved Al_2CuMg and Al_2Cu particles, for example, which particles can have an adverse effect on the fatigue crack growth resistance in the final product. In fact, if the reheat is below the solvus temperature, these particles can even grow in size. It is the presence of such constituent particles which can limit crack propagation resistance in the final sheet product.

In clad products, the temperature and duration of the reheat is very important for another reason. That is, if the

time at reheat temperature is excessive, copper can diffuse into the higher purity aluminum cladding which can detrimentally affect the corrosion protection afforded by the cladding.

After the reheat, the intermediate product is subjected to a second hot rolling operation. The second hot rolling operation is performed in the temperature range of about 500 to 900°F, preferably 600 to 850°F. The hot rolling may be performed to a final gauge, e.g., 0.25 inch or less. Alternatively, the hot rolling step can be performed to provide a second intermediate product having a thickness in the range of 0.1 to 0.3 inch. Thereafter, the second intermediate product can be cold rolled to a final gauge of 0.25 inch or less, typically in the range of 0.05 to 0.20 inch, to produce a substantially recrystallized product. An intermediate anneal may be used before cold rolling, if desired.

After cold rolling, the sheet product is then subjected to a solution heat treatment in the range of 910 to 945°F. It is important that the solution heat treatment be carefully controlled in duration. Thus, the solution heat treatment can be accomplished in 5 minutes or even less when the metal has reached the solution temperature. The time can be extended to 15 minutes or even 60 minutes. However, in clad product, care should be taken against diffusion of copper into the cladding and possible problems resulting therefrom.

Solution heat treatment in accordance with the present invention may be performed on a continuous basis. Basically, solution effects can occur fairly rapidly. In continuous

treating, the sheet is passed continuously as a single web through an elongated furnace which greatly increases the heat-up rate. Long solution heat treat times may be used to dissolve the soluble constituents such as Al_2CuMg and Al_2Cu. However, long time (more than 2 hours) solution heat treatments should not be used on clad products because of the excessive Cu diffusion that can occur in the cladding. The continuous approach facilitates practice of the invention since a relatively rapid heat-up and short dwell time at solution temperature result in minimizing copper dissolution into the cladding. Accordingly, the inventors contemplate solution heat treating in as little as about 10 minutes, or less, for instance about 0.5 to 4 minutes. As a further aid to achieving a short heat-up time, a furnace temperature or a furnace zone temperature significantly above the desired metal temperatures provides a greater temperature head useful to speed heat-up times.

After solution heat treatment, it is important that the metal be rapidly cooled to prevent or minimize the uncontrolled precipitation of secondary phases, e.g., Al_2CuMg and Al_2Cu. Thus, it is preferred in the practice of the invention that the quench rate be at least 100°F/sec from solution temperature to a temperature of 350°F or lower. A preferred quench rate is at least 300°F/sec in the temperature range of 925°F or more to 350°F or less. Suitable rates can be achieved with the use of water, e.g., water immersion or water jets. Further, air or air jets may be employed. Preferably, the quenching takes place on a continuous basis. The sheet may be cold worked, for example, by

stretching up to 10% of its original length. Typically, cold working or its equivalent which produces an effect similar to stretching, may be employed in the range of 0.5% to 6% of the products' original length.

After rapidly quenching, the sheet product is naturally aged. By natural aging is meant to include aging at temperatures up to 175°F.

Conforming to these controls greatly aids the production of sheet stock having high yield strength, improved levels of fracture toughness, increased resistance to fatigue crack growth and high resistance to corrosion, particularly using the alloy composition of the invention. That is, sheet can be produced having a minimum long transverse yield strength of 40 or 42 ksi, suitably minimum 44, 46 or 48 ksi, and a minimum fracture toughness of 140, 145 or 150 ksi √in. Also, the sheet has a fatigue crack growth rate of 10^{-4} inches per cycle at a minimum cyclic stress intensity range of 22 ksi √in.

Sheet fabricated in accordance with the invention has the advantage of maintaining relatively high yield strength, e.g., about 47 ksi, while increasing fracture toughness to about 150 to 165 ksi √in. Fracture toughness of the product in terms of measurements stated as K apparent (K app) using 16 inch wide panel can range from 88 or 90 to 100 ksi √in. As shown in Figure 2, the new product has considerably better resistance to fatigue crack propagation than existing fuselage skin alloys in tests conducted using a constant cyclic stress intensity factor range of 22 ksi√in. This cyclic stress intensity factor range is

important for the damage tolerant design of transport airplanes such as commercial airliners.

Sheet material of the invention is characterized by a substantial absence of secondary phase particles, e.g., Al_7Cu_2Fe, $Al_6(Fe, Mn)$ Al_2CuMg and Al_2Cu particles. That is, sheet material of the invention has generally less than 1.25 vol.% of such particles larger than 0.15 square μm as measured by optical image analysis through a cross section of the product.

That is, sheet material of the invention generally has a 500 to 530°C differential scanning calorimetry peak of less than 1.0 cal/gram. Figures 3 and 4 show a comparison between the new product and 2024-T3 which is the current material of choice for the fuselage skins of commercial jet aircraft.

Example

A 16 x 60 inch ingot having the composition 4.28% Cu, 1.38% Mg, 0.50% Mn, 0.07% Fe, 0.05% Si, balance Al was clad with AA1145 then heated to approximately 875°F and hot rolled to a slab gauge of 4.5 inches. The slab was then heated to a temperature above 910°F for 17 hours and hot rolled to a gauge of 0.176 inch. The metal was cold rolled to a final gauge of 0.100 inch before solution heat treating for 10 minutes at 925°F and stretching 1 to 3%. The sheet was aged for 3 weeks at room temperature.

For comparison, 2024-T3, which is currently used for the fuselage skins of commercial jet airliners, having the composition 4.6% Cu, 1.5% Mg, 0.6% Mn, 0.2% Fe, 0.2% Si, balance Al, was processed the same except it was not subjected to

reheating at 910°F.

The product of the invention had a 16% higher plane stress fracture toughness (K_C=156.5 ksi√in average of new product data of Fig. 1 versus 134.7 ksi√in average of highest two points of 2024 T-3 data of Fig. 1) and at a cyclic stress intensity range of 22 ksi√in the cracks grew 44% slower (da/dN=5.3×10^{-5} in/cycle versus 9.52×10^{-5} in/cycle) as shown in the table below. One possible explanation of the metallurgical causes of the improvement can be seen in Figures 3 and 4 which show differential scanning calorimetry curves. The size of the sharp peak that occurs in the temperature range of 500 to 530°C (Fig. 3) is indicative of the amount of constituent phase or phases such as Al_2CuMg and Al_2Cu present. These phases contribute to the lowering of fracture toughness and resistance to fatigue crack growth. The new product (Fig. 4) has a much smaller peak indicating that the volume fraction of such constituent has been significantly reduced in accordance with the present invention.

The volume fraction of total large constituent phase particles (including Fe and Si bearing particles), e.g., larger than 0.15 square µm, was much smaller for the new product than for the conventionally treated 2024-T3. In twelve measurements, the new product volume fraction ranged from 0.756% to 1.056%. In twelve measurements, the conventionally treated 2024-T3 constituent volume fraction ranged from 1.429% to 2.185%.

Fatigue Crack Propagation at
Different Cyclic Stress Intensity Ranges

Sample	ΔK	da/dN
New Product	10	6.70×10^{-6}
	22	5.30×10^{-5}
	30	1.34×10^{-4}
2024-T3	10	7.91×10^{-6}
	22	9.52×10^{-5}
	30	3.71×10^{-4}

ΔK=Cyclic Stress Intensity Factor Range
da/dN=Length of crack growth during one load/unload cycle
Test performed with a R-ratio (min. load/max. load) equal to 0.33.

Fracture toughness was measured using a 16-inch wide, 44-inch long panel. All values given were taken in the T-L orientation which means that the applied load was parallel to the transverse direction of the sheet and the crack propagated parallel to the longitudinal direction of the sheet. Fatigue crack growth resistance was measured as the length a crack propagates during each cycle at a given stress intensity range. The measurements were made with an R-ratio of 0.33 in the T-L orientation. It is readily seen that as the stress intensity factor increases, the extent of the improvement becomes more prominent.

Having thus described the invention, what is claimed is:

1. A method of producing an aluminum base alloy clad sheet product having high strength levels and good levels of fracture toughness and resistance to fatigue crack growth comprising:

(a) providing a body of an aluminum base alloy containing 4.0 to 4.5 wt.% Cu, 1.2 to 1.5 wt.% Mg, 0.4 to 0.7 wt.% Mn, 0.5 wt.% max. Fe, 0.5 wt.% max. Si, the remainder aluminum, incidental elements and impurities, the body having a cladding thereon of an aluminum;

(b) hot rolling the body to a slab;

(c) heating said slab to above 910°F to dissolve soluble constituents;

(d) hot rolling the slab in a temperature range of 600 to 850°F to a sheet product;

(e) solution heat treating;

(f) cooling; and

(g) naturally aging to provide a clad sheet product having high strength and improved levels of fracture toughness and resistance to fatigue crack growth.

2. The method in accordance with claim 1 wherein the body is hot rolled in a temperature range of 600 to 900°F prior to said heating.

8 3. The method in accordance with claim 1 wherein the sheet product is cold rolled to a final sheet gauge after said hot rolling.

4. The method in accordance with claim 1 wherein the sheet product has a gauge of 0.05 to 0.25 inch.

5. The method in accordance with claim 1 wherein the sheet product has a gauge of 0.05 to 0.15 inch.

6. The method in accordance with claim 1 wherein hot rolling is in a temperature range of 600 to 900°F.

a3 7. The method in accordance with claim 1 wherein the cladding is a higher purity aluminum alloy than said body.

8. The method in accordance with claim 1 wherein the cladding is selected from AA1100, 1200, 1230, 1135, 1235, 1435, 1145, 1345, 1250, 1350, 1170, 1175, 1180, 1185, 1285, 1188, 1199 or 7072.

9. The method in accordance with claim 1 wherein Cu is 4.1 to 4.5 wt.%.

10. The method in accordance with claim 1 wherein Mg is 1.2 to 1.4 wt.%.

11. The method in accordance with claim 1 wherein Fe is 0.12 wt.% max.

12. The method in accordance with claim 1 wherein Si is 0.1 wt.% max.

13. A method of producing an aluminum base alloy clad sheet product having high strength levels and good levels of fracture toughness and resistance to fatigue crack growth comprising:

(a) providing a body of an aluminum base alloy containing 4.1 to 4.4 wt.% Cu, 1.2 to 1.45 wt.% Mg, 0.4 to 0.6 wt.% Mn, 0.12 wt.% max. Fe, 0.1 wt.% max. Si, the remainder aluminum, incidental elements and impurities, the body having a cladding thereon of essentially aluminum;

(b) hot rolling the body to a slab in a temperature range of 600 to 900°F;

(c) reheating said slab to above 910°F;

(d) hot rolling the slab in a temperature range of 600 to 900°F to a sheet product;

(e) solution heat treating for a time of less than 60 minutes in a temperature range of 910 to 1050°F;

(f) rapidly cooling; and

(g) aging to provide a clad sheet product having high strength and good levels of fracture toughness and resistance to fatigue crack growth.

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14. The method in accordance with claim 13 wherein the sheet is solution heat treated in a temperature range of 910 to 945°F.

15. The method in accordance with claim 13 wherein the sheet is solution heat treated for less than 15 minutes.

16. The method in accordance with claim 13 wherein the sheet is cold water quenched.

17. The method in accordance with claim 13 wherein the sheet is naturally aged.

18. The method in accordance with claim 13 wherein the body is provided with an aluminum cladding selected from AA1100, 1200, 1230, 1135, 1235, 1435, 1145, 1345, 1250, 1350, 1170, 1175, 1180, 1185, 1285, 1188, 1199 or 7072.

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19. The method in accordance with claim 13 wherein after hot rolling the sheet is cold rolled to a cold rolled gauge in the range of 0.05 to 0.25 inch.

20. A method of producing an aluminum base alloy clad sheet product having high strength levels and good levels of fracture toughness and resistance to fatigue crack growth comprising:

(a) providing a body of an aluminum base alloy containing 4.0 to 4.5 wt.% Cu, 1.2 to 1.4 wt.% Mg, 0.4 to 0.6 wt.% Mn, 0.5 wt.% max. Fe, 0.5 wt.% max. Si, the remainder aluminum, incidental elements and impurities, the body having a cladding thereon of an aluminum alloy;

(b) hot rolling the body to a slab in a temperature range of 600 to 900°F;

(c) heating said slab to above 910°F;

(d) hot rolling the slab in a temperature range of 600 to 900°F to a sheet product;

(e) cold rolling to a sheet gauge having a thickness in the range of 0.05 to 0.25 inch;

(f) solution heat treating for a time of less than 15 minutes in a temperature range of 910 to 1050°F;

(g) rapidly cooling; and

(h) naturally aging to provide a clad sheet product having high strength and good levels of fracture toughness and resistance to fatigue crack growth.

21. A method of producing an aluminum base alloy clad sheet product having high strength and improved levels of fracture toughness and fatigue crack growth resistance comprising:

(a) providing a body of an aluminum base alloy containing 4.1 to 4.4 wt.% Cu, 1.2 to 1.45 wt.% Mg, 0.4 to 0.6 wt.% Mn, 0.12 wt.% max. Fe, 0.1 wt.% max. Si, the remainder aluminum, incidental elements and impurities, the body having a cladding thereon of aluminum;

(b) hot rolling the body to a slab in a temperature in the range of 600 to 900°F;

(c) reheating said slab to 910 to 945°F to dissolve soluble constituents;

(d) hot rolling the slab in a temperature range of 600 to 850°F;

(e) cold rolling to a sheet gauge product having a thickness in the range of 0.05 to 0.25 inch;

(f) solution heat treating said product for a time of less than 15 minutes at a solution heat treating temperature in the range of 910 to 1050°F;

(g) rapidly cooling; and

(h) naturally aging said product to provide a clad sheet product having high strength and improved levels of fracture toughness and resistance to fatigue crack growth.

22. A method of producing an aluminum base alloy clad sheet product having high strength levels and improved levels of fracture toughness and resistance to fatigue crack growth comprising:

(a) providing a body of an aluminum base alloy containing 4.1 to 4.5 wt.% Cu, 1.2 to 1.5 wt.% Mg, 0.4 to 0.6 wt.% Mn, 0.12 wt.% max. Fe, 0.1 wt.% max. Si, the remainder aluminum, incidental elements and impurities, the body having a cladding thereon of an aluminum selected from AA1100, 1200, 1230, 1135, 1235, 1435, 1145, 1345, 1250, 1350, 1170, 1175, 1180, 1185, 1285, 1188, 1199 or 7072;

(b) hot rolling the body to a slab in a temperature range of 600 to 900°F;

(c) reheating said slab to above 910°F to dissolve soluble constituents;

(d) hot rolling the slab in a temperature range of 600 to 850°F;

(e) cold rolling to a sheet gauge having a thickness in the range of 0.05 to 0.25 inch;

(f) solution heat treating for a time of less than 15 minutes in a temperature range of 910 to 1050°F;

(g) rapidly cooling; and

(h) naturally aging to provide a clad sheet product having high strength and improved levels of fracture toughness and resistance to fatigue crack growth.

23. In a method of producing an aluminum base alloy clad aircraft skin wherein an aluminum alloy product is formed to produce said aircraft skin, the improvement wherein said product is provided as an aluminum base alloy containing 4.0 to 4.5 wt.% Cu, 1.2 to 1.45 wt.% Mg, 0.4 to 0.6 wt.% Mn, 0.12 wt.% max. Fe, 0.1 wt.% max. Si, the remainder aluminum, incidental elements and impurities, the product having a cladding thereon of aluminum, the product further provided in the condition resulting from:

(a) hot rolling said alloy to a slab in a temperature range of 600 to 900°F;

(b) heating said slab to above 910°F to dissolve soluble constituents;

(c) hot rolling the slab in a temperature range of 600 to 900°F to a sheet product;

(d) solution heat treating the sheet product;

(e) cooling; and

(f) naturally aging to provide a clad sheet product having high strength and good levels of fracture toughness and resistance to fatigue crack growth.

24. The method in accordance with claim 23 wherein the body is hot rolled in a temperature range of 600 to 900°F prior to said heating step.

25. The method in accordance with claim 23 wherein the sheet product is cold rolled to a final sheet gauge after said hot rolling step.

26. The method in accordance with claim 23 wherein the sheet product has a gauge of 0.05 to 0.25 inch.

27. The method in accordance with claim 23 wherein the sheet product has a gauge of 0.05 to 0.15 inch.

28. The method in accordance with claim 23 wherein hot rolling is in a temperature range of 600 to 900°F.

26 29. The method in accordance with claim 23 wherein the cladding is a higher purity aluminum alloy than said body.

30. The method in accordance with claim 23 wherein the cladding is selected from AA1100, 1200, 1230, 1135, 1235, 1435, 1145, 1345, 1250, 1350, 1170, 1175, 1180, 1185, 1285, 1188, 1199 or 7072.

31. The method in accordance with claim 23 wherein Cu is 4.1 to 4.4 wt.%.

32. The method in accordance with claim 23 wherein Mg is 1.2 to 1.4 wt.%.

33. In a method of producing an aluminum base alloy clad aircraft skin wherein an aluminum alloy sheet product is formed to produce said aircraft skin product, the improvement wherein said sheet product is provided as an aluminum base alloy containing 4.1 to 4.4 wt.% Cu, 1.2 to 1.45 wt.% Mg, 0.4 to 0.6 wt.% Mn, 0.12 wt.% max. Fe, 0.1 wt.% max. Si, the remainder aluminum, incidental elements and impurities, the sheet product having a cladding thereon of aluminum, the sheet product further provided in the condition resulting from:

(a) hot rolling the alloy to a slab in a temperature range of 600 to 900°F;

(b) heating said slab to above 910°F to dissolve soluble constituents;

(c) hot rolling the slab in a temperature in the range of 600 to 900°F to a sheet product;

(d) solution heat treating for a time of less than 15 minutes in a temperature range of 910 to 1050°F;

(e) rapidly cooling; and

(f) naturally aging to provide a clad sheet product having high strength and good levels of fracture toughness and resistance to fatigue crack growth.

34. The method in accordance with claim 33 wherein the sheet is solution heat treated in a temperature range of 910 to 945°F.

35. The method in accordance with claim 33 wherein the sheet is solution heat treated for less than 15 minutes.

36. The method in accordance with claim 33 wherein the sheet is cold water quenched.

37. The method in accordance with claim 33 wherein the sheet is naturally aged.

38. The method in accordance with claim 33 wherein the body is provided with a cladding selected from AA1100, 1200, 1230, 1135, 1235, 1435, 1145, 1345, 1250, 1350, 1170, 1175, 1180, 1185, 1285, 1188, 1199 or 7072.

18 ~~39. The method in accordance with claim 33 wherein the sheet is cold rolled after the last hot rolling step to a gauge in the range of 0.05 to 0.25 inch.~~

40. In a method of producing a damage tolerant aluminum base alloy clad aircraft fuselage skin product, the improvement wherein said product is provided as an aluminum base alloy containing 4.0 to 4.5 wt.% Cu, 1.2 to 1.45 wt.% Mg, 0.4 to 0.6 wt.% Mn, 0.12 wt.% max. Fe, 0.1 wt.% max. Si, the remainder aluminum, incidental elements and impurities, the product having a cladding thereon of AA1000 series aluminum alloy, the product further provided in the condition resulting from:

(a) hot rolling and bonding the cladding to said alloy in a temperature range of 600 to 900°F to form a slab;

(b) heating said slab to above 910°F;

(c) hot rolling the slab in a temperature range of 600 to 900°F;

(d) cold rolling to a sheet gauge having a thickness in the range of 0.05 to 0.25 inch;

(e) solution heat treating for a time of less than 15 minutes in a temperature range of 910 to 1050°F;

(f) rapidly cooling; and

(g) naturally aging to provide a clad sheet product having high strength and good levels of fracture toughness and resistance to fatigue crack growth.

41. In a method of producing a damage tolerant aluminum base alloy clad aircraft wing skin product, the improvement wherein said product is provided as an aluminum base alloy containing 4.0 to 4.5 wt.% Cu, 1.2 to 1.5 wt.% Mg, 0.4 to 0.6 wt.% Mn, 0.12 wt.% max. Fe, 0.1 wt.% max. Si, the remainder aluminum, incidental elements and impurities, the product having a cladding thereon of essentially aluminum, the product further provided in the condition resulting from:

(a) hot rolling the alloy to a slab in a temperature range of 600 to 900°F;

(b) heating said slab to above 910°F;

(c) hot rolling the slab in a temperature range of 600 to 850°F to a sheet product;

(d) cold rolling to a sheet gauge having a thickness in the range of 0.05 to 0.25 inch;

(e) solution heat treating for a time of less than 15 minutes in a temperature range of 910 to 1050°F; and

(f) rapidly cooling; and

(g) naturally aging to provide a clad sheet product having high strength and good levels of fracture toughness and resistance to fatigue crack growth.

42. A damage tolerant aluminum base alloy clad sheet product having high strength and improved levels of fracture toughness and resistance to fatigue crack growth, the sheet having a core of an aluminum base alloy containing 4.0 to 4.5 wt.% Cu, 1.2 to 1.45 wt.% Mg, 0.4 to 0.6 wt.% Mn, 0.12 wt.% max. Fe, 0.1 wt.% max. Si, the remainder aluminum and incidental elements and impurities, the sheet having a minimum long transverse yield strength of 40 ksi, a minimum T-L fracture of 140 ksi √in.

43. The sheet product in accordance with claim 42 wherein the product has a minimum long transverse yield strength of 44 ksi.

44. The sheet product in accordance with claim 42 wherein the product has a minimum T-L fracture toughness of 144 ksi √in.

45. The sheet product in accordance with claim 42 wherein the product has a T-L fatigue crack growth rate of 10^{-4} inches per cycle at a minimum cyclic stress intensity range of 22 ksi √in.

46. The sheet product in accordance with claim 42 wherein the product has a volume fraction of particles including Al_2CuMg and Al_2Cu less than 1.25 vol.% larger than 0.15 square µm.

47. The sheet product in accordance with claim 42 wherein the product has a volume fraction of particles including Al_2CuMg and Al_2Cu less than 1 vol.% larger than 0.15 square µm.

48. The sheet product in accordance with claim 42 wherein the product has a thickness of 0.05 to 0.25 inch.

49. The sheet product in accordance with claim 42 wherein the product is solution heat treated, quenched and naturally aged.

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50. The sheet product in accordance with claim 42 wherein the product is recrystallized.

51. A damage tolerant aluminum base alloy clad sheet product having high strength and improved levels of fracture toughness and resistance to fatigue crack growth in the solution heat treated, quenched and aged condition, the sheet having a core of an aluminum base alloy containing 4.0 to 4.5 wt.% Cu, 1.2 to 1.5 wt.% Mg, 0.4 to 0.6 wt.% Mn, 0.12 wt.% max. Fe, 0.1 wt.% max. Si, the remainder aluminum and incidental elements and impurities, the sheet having a minimum long transverse yield strength of 42 ksi, the sheet having a cladding of aluminum selected from AA1145, 1230, 1060 and 1100, the sheet having a thickness of 0.05 to 0.25 inch, a minimum T-L fracture toughness of 140 ksi √in, the core having a volume fraction of particles including Al_2CuMg and Al_2Cu less than 1.25 vol.% larger than 0.15 square μm.

52. A damage tolerant aircraft skin comprised of a core of aluminum base alloy, the core having a cladding of aluminum thereon of the AA1000 series, the skin having high strength and improved levels of fracture toughness and resistance to fatigue crack growth, the skin having a core of an aluminum base alloy containing 4.0 to 4.5 wt.% Cu, 1.2 to 1.45 wt.% Mg, 0.4 to 0.6 wt.% Mn, 0.1 wt.% max. Fe, 0.1 wt.% max. Si, the remainder aluminum and incidental elements and impurities, the skin having a minimum long transverse yield strength of 40 ksi, a minimum T-L fracture toughness of 140 ksi √in.

53. A damage tolerant aircraft skin comprised of a core of aluminum base alloy, the core having a cladding of an aluminum alloy thereon, the skin having high strength and improved levels of fracture toughness and resistance to fatigue crack growth in the solution heat treated, quenched and naturally aged condition, the skin having a core of an aluminum base alloy containing 4.0 to 4.5 wt.% Cu, 1.2 to 1.5 wt.% Mg, 0.4 to 0.6 wt.% Mn, 0.1 wt.% max. Fe, 0.1 wt.% max. Si, the remainder aluminum and incidental elements and impurities, the skin having a minimum long transverse yield strength of 42 ksi, the skin having a cladding of an aluminum alloy selected from AA1145, 1230, 1060 and 1100, the skin having a thickness of 0.05 to 0.25 inch, a minimum T-L fracture toughness of 140 ksi √in, the core having a volume fraction of particles including Al_2CuMg and Al_2Cu less 1.25 vol.% larger than 0.15 square μm.

54. A damage tolerant aircraft fuselage skin comprised of a core of aluminum base alloy, the core having a cladding of aluminum thereon, the skin having high strength and improved levels of fracture toughness and resistance to fatigue crack growth, the skin having a core of an aluminum base alloy containing 4.0 to 4.5 wt.% Cu, 1.2 to 1.5 wt.% Mg, 0.4 to 0.6 wt.% Mn, 0.12 wt.% max. Fe, 0.1 wt.% max. Si, the remainder aluminum and incidental elements and impurities, the skin having a minimum long transverse yield strength of 40 ksi, a minimum T-L fracture toughness of 140 ksi √in.

55. A damage tolerant aircraft fuselage skin comprised of a core of aluminum base alloy, the core having a cladding of an aluminum alloy thereon, the skin having high strength and improved levels of fracture toughness and resistance to fatigue crack growth in the solution heat treated, quenched and naturally aged condition, the skin having a core of an aluminum base alloy containing 4.0 to 4.5 wt.% Cu, 1.2 to 1.5 wt.% Mg, 0.4 to 0.6 wt.% Mn, 0.12 wt.% max. Fe, 0.1 wt.% max. Si, the remainder aluminum and incidental elements and impurities, the skin having a minimum T-L yield strength of 42 ksi, the skin having a cladding selected from AA1145, 1230, 1060 and 1350, the skin having a thickness of 0.05 to 0.25 inch, a minimum T-L fracture toughness of 140 ksi √in, the core having a volume fraction of particles including Al_2CuMg and Al_2Cu less 1.25 vol.% larger than 0.15 square μm.

56. A damage tolerant aircraft wing skin comprised of a core of aluminum base alloy, the core having a cladding of an aluminum alloy thereon, the skin having high strength and improved levels of fracture toughness and resistance to fatigue crack growth, the skin having a core of an aluminum base alloy containing 4.0 to 4.5 wt.% Cu, 1.2 to 1.5 wt.% Mg, 0.4 to 0.6 wt.% Mn, 0.12 wt.% max. Fe, 0.1 wt.% max. Si, the remainder aluminum and incidental elements and impurities, the skin having a minimum long transverse yield strength of 40 ksi, a minimum T-L fracture toughness of 140 ksi √in.

57. A damage tolerant aircraft wing skin comprised of a core of aluminum base alloy, the core having a cladding of an aluminum alloy thereon, the skin having high strength and improved levels of fracture toughness and resistance to fatigue crack growth in the solution heat treated, quenched and naturally aged condition, the skin having a core of an aluminum base alloy containing 4.0 to 4.5 wt.% Cu, 1.2 to 1.5 wt.% Mg, 0.4 to 0.6 wt.% Mn, 0.12 wt.% max. Fe, 0.1 wt.% max. Si, the remainder aluminum and incidental elements and impurities, the skin having a minimum long transverse yield strength of 42 ksi, the skin having a cladding of an aluminum alloy selected from AA1145, 1230, 1060 and 1100, the skin having a thickness of 0.05 to 0.25 inch, a minimum T-L fracture toughness of 140 ksi √in, the core having a volume fraction of particles including Al_2CuMg and Al_2Cu less 1.25 vol.% larger than 0.15 square μm.

58. A method of producing an aluminum base alloy clad sheet product having high strength levels and good levels of fracture toughness and resistance to fatigue crack growth comprising:

(a) providing a body of an aluminum base alloy containing 3.8 to 4.5 wt.% Cu, 1.2 to 1.85 wt.% Mg, 0.3 to 0.78 wt.% Mn, 0.5 wt.% max. Fe, 0.5 wt.% max. Si, the remainder aluminum, incidental elements and impurities, the body having a cladding thereon of an aluminum;

(b) hot rolling the body to a slab;

(c) heating said slab to above 910°F to dissolve soluble constituents;

(d) hot rolling the slab in a temperature range of 600 to 850°F to a sheet product;

(e) solution heat treating;

(f) cooling; and

(g) naturally aging to provide a clad sheet product having high strength and improved levels of fracture toughness and resistance to fatigue crack growth.

59. A method of producing an aluminum base alloy clad sheet product having high strength levels and good levels of fracture toughness and resistance to fatigue crack growth comprising:

(a) providing a body of an aluminum base alloy containing 3.8 to 4.5 wt.% Cu, 1.2 to 1.85 wt.% Mg, 0.3 to 0.78 wt.% Mn, 0.5 wt.% max. Fe, 0.5 wt.% max. Si, the remainder aluminum, incidental elements and impurities, the body having a cladding thereon of essentially aluminum;

(b) hot rolling the body to a slab in a temperature range of 600 to 900°F;

(c) reheating said slab to above 910°F;

(d) hot rolling the slab in a temperature range of 600 to 900°F to a sheet product;

(e) solution heat treating for a time of less than 60 minutes in a temperature range of 910 to 1050°F;

(f) rapidly cooling; and

(g) aging to provide a clad sheet product having high strength and good levels of fracture toughness and resistance to fatigue crack growth.

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60. A method of producing an aluminum base alloy clad sheet product having high strength levels and good levels of fracture toughness and resistance to fatigue crack growth comprising:

(a) providing a body of an aluminum base alloy containing 3.8 to 4.5 wt.% Cu, 1.2 to 1.85 wt.% Mg, 0.3 to 0.78 wt.% Mn, 0.5 wt.% max. Fe, 0.5 wt.% max. Si, the remainder aluminum, incidental elements and impurities, the body having a cladding thereon of an aluminum alloy;

(b) hot rolling the body to a slab in a temperature range of 600 to 900°F;

(c) heating said slab to above 910°F;

(d) hot rolling the slab in a temperature range of 600 to 900°F to a sheet product;

(e) cold rolling to a sheet gauge having a thickness in the range of 0.05 to 0.25 inch;

(f) solution heat treating for a time of less than 15 minutes in a temperature range of 910 to 1050°F;

(g) rapidly cooling; and

(h) naturally aging to provide a clad sheet product having high strength and good levels of fracture toughness and resistance to fatigue crack growth.

61. A method of producing an aluminum base alloy clad sheet product having high strength levels and improved levels of fracture toughness and resistance to fatigue crack growth comprising:

(a) providing a body of an aluminum base alloy containing 3.8 to 4.5 wt.% Cu, 1.2 to 1.85 wt.% Mg, 0.3 to 0.78 wt.% Mn, 0.5 wt.% max. Fe, 0.5 wt.% max. Si, the remainder aluminum, incidental elements and impurities, the body having a cladding thereon of an aluminum selected from AA1100, 1200, 1230, 1135, 1235, 1435, 1145, 1345, 1250, 1350, 1170, 1175, 1180, 1185, 1285, 1188, 1199 or 7072;

(b) hot rolling the body to a slab in a temperature range of 600 to 900°F;

(c) reheating said slab to above 910°F to dissolve soluble constituents;

(d) hot rolling the slab in a temperature range of 600 to 850°F;

(e) cold rolling to a sheet gauge having a thickness in the range of 0.05 to 0.25 inch;

(f) solution heat treating for a time of less than 15 minutes in a temperature range of 910 to 1050°F;

(g) rapidly cooling; and

(h) naturally aging to provide a clad sheet product having high strength and improved levels of fracture toughness and resistance to fatigue crack growth.

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62. In a method of producing an aluminum base alloy clad aircraft skin wherein an aluminum alloy product is formed to produce said aircraft skin, the improvement wherein said product is provided as an aluminum base alloy containing 3.8 to 4.5 wt.% Cu, 1.2 to 1.85 wt.% Mg, 0.3 to 0.78 wt.% Mn, 0.5 wt.% max. Fe, 0.5 wt.% max. Si, the remainder aluminum, incidental elements and impurities, the product having a cladding thereon of aluminum, the product further provided in the condition resulting from:

(a) hot rolling said alloy to a slab in a temperature range of 600 to 900°F;

(b) heating said slab to above 910°F to dissolve soluble constituents;

(c) hot rolling the slab in a temperature range of 600 to 900°F to a sheet product;

(d) solution heat treating the sheet product;

(e) cooling; and

(f) naturally aging to provide a clad sheet product having high strength and good levels of fracture toughness and resistance to fatigue crack growth.

63. In a method of producing an aluminum base alloy clad aircraft skin wherein an aluminum alloy sheet product is formed to produce said aircraft skin product, the improvement wherein said sheet product is provided as an aluminum base alloy containing 3.8 to 4.5 wt.% Cu, 1.2 to 1.85 wt.% Mg, 0.3 to 0.78 wt.% Mn, 0.5 wt.% max. Fe, 0.5 wt.% max. Si, the remainder aluminum, incidental elements and impurities, the sheet product having a cladding thereon of aluminum, the sheet product further provided in the condition resulting from:

A10

(a) hot rolling the alloy to a slab in a temperature range of 600 to 900°F;

(b) heating said slab to above 910°F to dissolve soluble constituents;

(c) hot rolling the slab in a temperature in the range of 600 to 900°F to a sheet product;

(d) solution heat treating for a time of less than 15 minutes in a temperature range of 910 to 1050°F;

(e) rapidly cooling; and

(f) naturally aging to provide a clad sheet product having high strength and good levels of fracture toughness and resistance to fatigue crack growth.

64. In a method of producing a damage tolerant aluminum base alloy clad aircraft fuselage skin product, the improvement wherein said product is provided as an aluminum base alloy containing 3.8 to 4.5 wt.% Cu, 1.2 to 1.85 wt.% Mg, 0.3 to 0.78 wt.% Mn, 0.5 wt.% max. Fe, 0.5 wt.% max. Si, the remainder aluminum, incidental elements and impurities, the product having a cladding thereon of AA1000 series aluminum alloy, the product further provided in the condition resulting from:

(a) hot rolling and bonding the cladding to said alloy in a temperature range of 600 to 900°F to form a slab;

(b) heating said slab to above 910°F;

(c) hot rolling the slab in a temperature range of 600 to 900°F;

(d) cold rolling to a sheet gauge having a thickness in the range of 0.05 to 0.25 inch;

(e) solution heat treating for a time of less than 15 minutes in a temperature range of 910 to 1050°F;

(f) rapidly cooling; and

(g) naturally aging to provide a clad sheet product having high strength and good levels of fracture toughness and resistance to fatigue crack growth.

11/572625

Strength versus Toughness Plot for New Product and 2024-T3

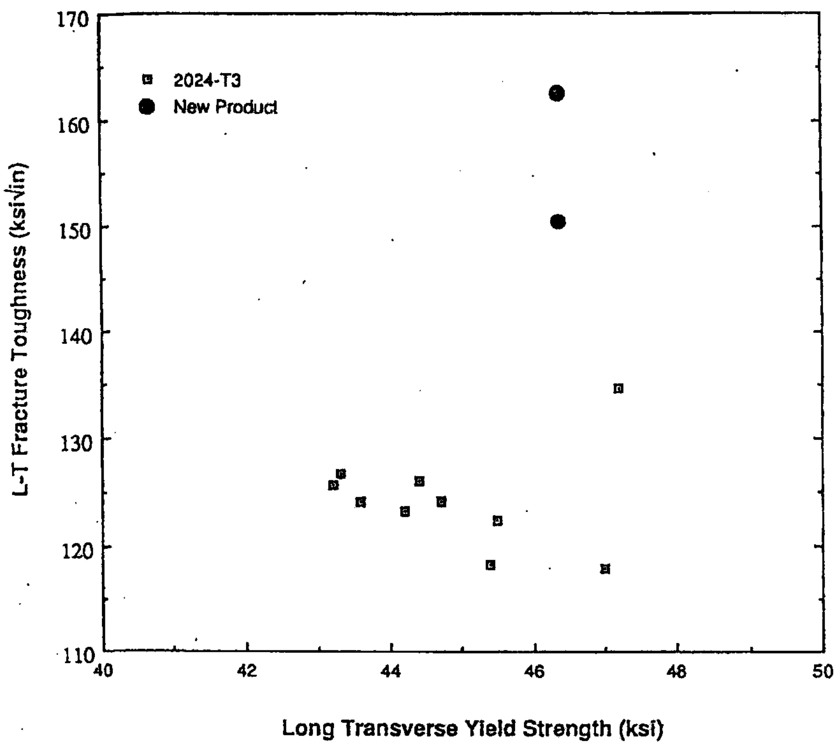


FIGURE 1

07/572625

FATIGUE CRACK GROWTH RATE VS. CRACK LENGTH
FOR 2024-T3 AND THE IMPROVED PRODUCT
ΔK=22 ksi√in., R=0.33, T-L ORIENTATION

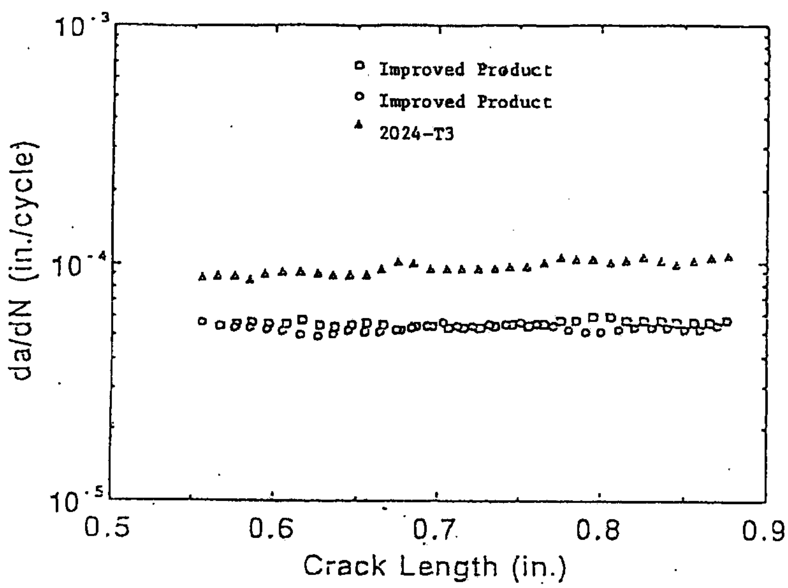
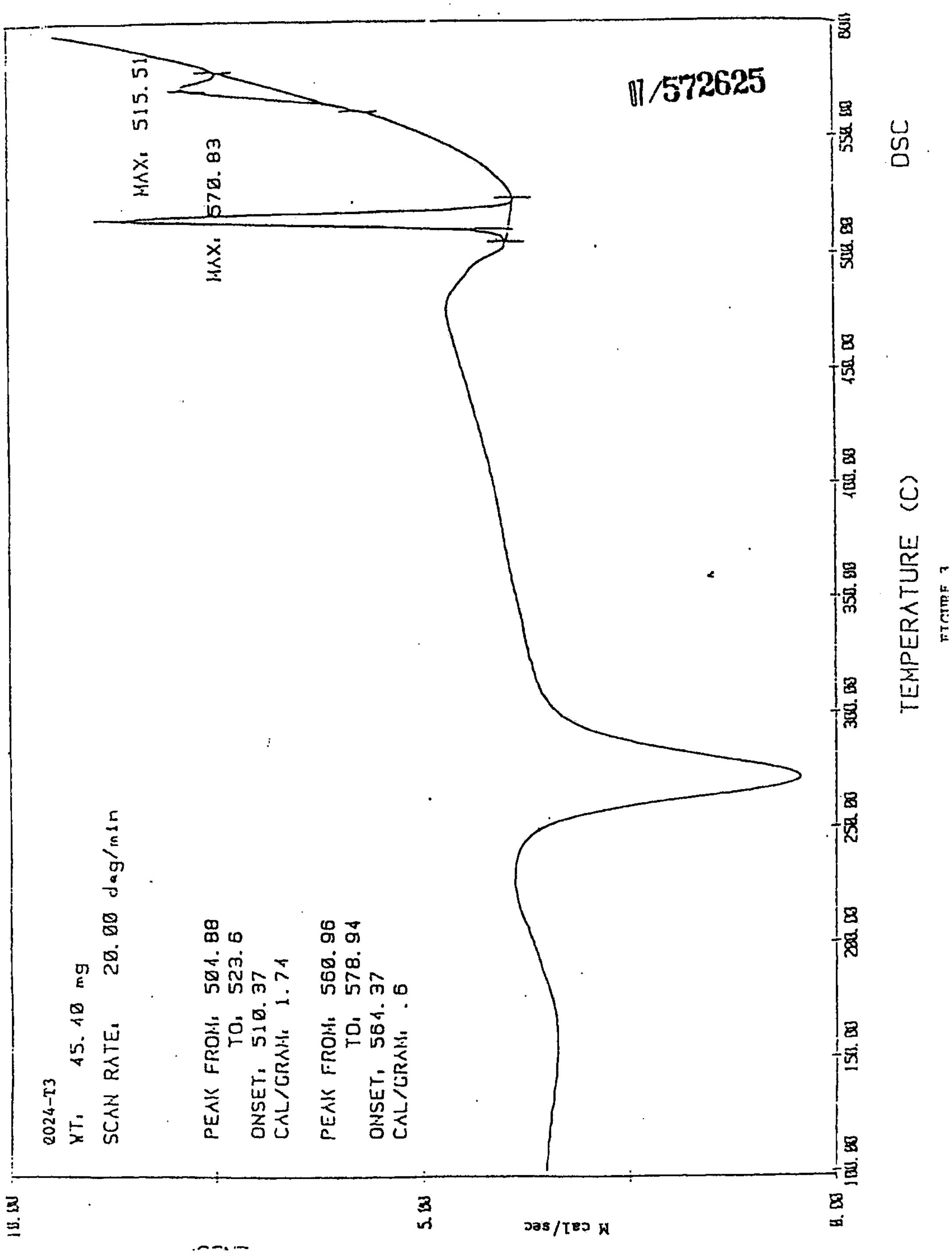


FIGURE 2


2024-T3
WT: 45.40 mg
SCAN RATE: 20.00 deg/min
PEAK FROM: 504.88
TO: 523.6
ONSET: 510.37
CAL/GRAM: 1.74
PEAK FROM: 560.96
TO: 578.94
ONSET: 564.37
CAL/GRAM: .6
MAX: 515.51
MAX: 570.83
11/572625
M cal/sec
TEMPERATURE (C)
DSC

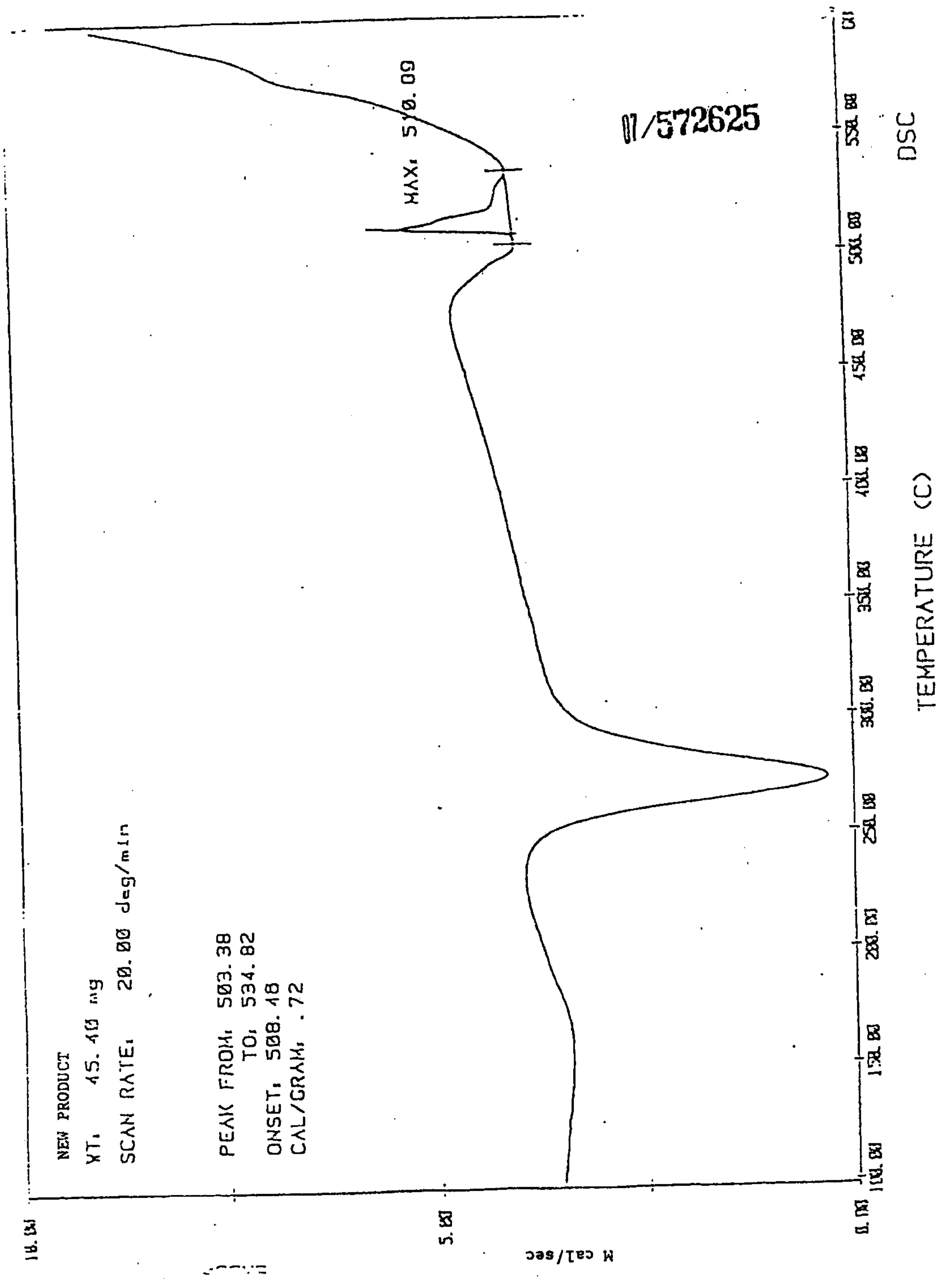

NEW PRODUCT
WT: 45.40 mg
SCAN RATE: 20.00 deg/min
PEAK FROM: 503.38
TO: 534.82
ONSET: 508.48
CAL/GRAM: .72
MAX: 510.09
07/572625
DSC
TEMPERATURE (C)
M cal/sec
10.00
5.00
0.00
100.00
150.00
200.00
250.00
300.00
350.00
400.00
450.00
500.00
550.00

FIGURE 4

Exhibit 2

[redacted]

ABANDONED

ABANDONED

SERIAL NUMBER (Series of 1987)	PATENT DATE	PATENT NUMBER
07/572,625		

SERIAL NUMBER	FILING DATE	CLASS	SUBCLASS	GROUP ART UNIT	EXAMINER
07/572,625	08/27/90	148	~~12.7A~~ 693	111	~~SCHUMAKER~~ KOEHLER

APPLICANT

EDWARD L. COLVIN, PITTSBURGH, PA; JOCELYN I. PETIT, NEW KENSINGTON, PA; ROBERT W. WESTERLUND, BETTENDORF, IA.

CONTINUING DATA*******************
VERIFIED
RRK

FOREIGN/PCT APPLICATIONS**********
VERIFIED
RRK

NOTE - DISCLAIMER
The term of this patent subsequent to ________ has been disclaimed

Foreign priority claimed 35 USC 119 conditions met / Verified and Acknowledged		AS FILED	STATE OR COUNTRY	SHEETS DRWGS	TOTAL CLAIMS	INDEP CLAIMS	FILING FEE RECEIVED	ATTORNEY'S DOCKET NO.
☐ yes ☒ no / ☐ yes ☒ no	RRK Examiner's initials	→	PA	4	64	~~3~~ 24	$1,654.00	

ADDRESS

ANDREW ALEXANDER
ALUMINUM COMPANY OF AMERICA
ALCOA CENTER, PA 15069

TITLE

DAMAGE TOLERANT ALUMINUM ALLOY CLAD SHEET FOR AIRCRAFT SKIN

U.S. DEPT. of COMM.- Pat. & TM Office—PTO-436L (rev. 10-78)

PARTS OF APPLICATION FILED SEPARATELY

NOTICE OF ALLOWANCE MAILED	PREPARED FOR ISSUE	CLAIMS ALLOWED
July 1, 1992	Robert R. Koehler (Assistant Examiner) / A. Thompson (Docket Clerk)	Total Claims: 64 / Print Claim: 1

ISSUE FEE			DRAWING		
Amount Due	Date Paid	R. DEAN PRIMARY EXAMINER GROUP 110 - ART UNIT 111 RD 11/01 (Primary Examiner)	Sheets Drwg.	Figs. Drwg.	Print Fig.
$1130.00			4	4	1

FORM PTO-1267 U.S. DEPT. OF COMMERCE (REV. 6-78) PAT. & TM OFF.

DISCLAIMER LABEL

SERIAL NO.	FILING DATE
572,625	08/27/90

Terminal disclaimer has been entered and recorded under 35 U.S.C. 253 in this file by Issue Division.

ISSUE CLASSIFICATION		ISSUE BATCH NUMBER
Class	Subclass	
148	693	E26

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SERIAL NUMBER	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.
07/572,625	08/27/90	COLVIN	E

EXAMINER
KOEHLER, R

ANDREW ALEXANDER
ALUMINUM COMPANY OF AMERICA
ALCOA CENTER, PA 15069

ART UNIT	PAPER NUMBER
111	6

DATE MAILED: 08/22/91

This is a communication from the examiner in charge of your application.
COMMISSIONER OF PATENTS AND TRADEMARKS

☒ This application has been examined ☐ Responsive to communication filed on ____________ ☐ This action is made final.

A shortened statutory period for response to this action is set to expire 3 month(s), ______ days from the date of this letter.
Failure to respond within the period for response will cause the application to become abandoned. 35 U.S.C. 133

Part I THE FOLLOWING ATTACHMENT(S) ARE PART OF THIS ACTION:

1. ☒ Notice of References Cited by Examiner, PTO-892.
2. ☒ Notice re Patent Drawing, PTO-948.
3. ☒ Notice of Art Cited by Applicant, PTO-1449.
4. ☐ Notice of Informal Patent Application, Form PTO-152
5. ☐ Information on How to Effect Drawing Changes, PTO-1474.
6. ☐ ____________

Part II SUMMARY OF ACTION

1. ☒ Claims 1 to 64 are pending in the application.

   Of the above, claims ____________ are withdrawn from consideration.

2. ☐ Claims ____________ have been cancelled.

3. ☐ Claims ____________ are allowed.

4. ☒ Claims 1 to 64 are rejected.

5. ☐ Claims ____________ are objected to.

6. ☐ Claims ____________ are subject to restriction or election requirement.

7. ☒ This application has been filed with informal drawings under 37 C.F.R. 1.85 which are acceptable for examination purposes.

8. ☐ Formal drawings are required in response to this Office action.

9. ☐ The corrected or substitute drawings have been received on ____________. Under 37 C.F.R. 1.84 these drawings are ☐ acceptable; ☐ not acceptable (see explanation or Notice re Patent Drawing, PTO-948).

10. ☐ The proposed additional or substitute sheet(s) of drawings, filed on ____________, has (have) been ☐ approved by the examiner; ☐ disapproved by the examiner (see explanation).

11. ☐ The proposed drawing correction, filed ____________, has been ☐ approved; ☐ disapproved (see explanation).

12. ☐ Acknowledgement is made of the claim for priority under U.S.C. 119. The certified copy has ☐ been received ☐ not been received ☐ been filed in parent application, serial no. ____________; filed on ____________.

13. ☐ Since this application appears to be in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under Ex parte Quayle, 1935 C.D. 11; 453 O.G. 213.

14. ☐ Other

EXAMINER'S ACTION

PTOL-326 (Rev.9-89)

The following is a quotation of the appropriate paragraphs of 35 U.S.C. § 102 that form the basis for the rejections under this section made in this Office action:

> A person shall be entitled to a patent unless --
> (b) the invention was patented or described in a printed publication in this or a foreign country or in public use or on sale in this country, more than one year prior to the date of application for patent in the United States.
>
> (e) the invention was described in a patent granted on an application for patent by another filed in the United States before the invention thereof by the applicant for patent, or on an international application by another who has fulfilled the requirements of paragraphs (1), (2), and (4) of section 371(c) of this title before the invention thereof by the applicant for patent.

Claims 1 to 41 and 58 to 64 are rejected under 35 U.S.C. § 102(b) and (e) as being anticipated by Cho (U.S. Patent No. 4,816,087).

Cho discloses process steps for alloy AA2024 involving hot working, reheating the alloy, a second hot working, solution heat treating, rapid cooling, and natural aging with process times and temperatures that overlap applicants' claimed procedure for these Al-Cu-Mg alloys. See lines 42 to 68 in column 5, lines 8 to 9 in column 6, and lines 14 to 17 in column 7.

The following is a quotation of 35 U.S.C. § 103 which forms the basis for all obviousness rejections set forth in this Office action:

> A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary

> skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.
>
> Subject matter developed by another person, which qualifies as prior art only under subsection (f) or (g) of section 102 of this title, shall not preclude patentability under this section where the subject matter and the claimed invention were, at the time the invention was made, owned by the same person or subject to an obligation of assignment to the same person.

This application currently names joint inventors. In considering patentability of the claims under 35 U.S.C. § 103, the examiner presumes that the subject matter of the various claims was commonly owned at the time any inventions covered therein were made absent any evidence to the contrary. Applicant is advised of the obligation under 37 C.F.R. § 1.56 to point out the inventor and invention dates of each claim that was not commonly owned at the time a later invention was made in order for the examiner to consider the applicability of potential 35 U.S.C. § 102(f) or (g) prior art under 35 U.S.C. § 103.

Claims 1 to 64 are rejected under 35 U.S.C. § 103 as being unpatentable over Cho (U.S. Patent No. 4,816,087) in view o Hyatt, et al. (U.S. Patent No. 4,294,625).

Cho discloses a process of heat treating Al-Cu-mg alloys (similar to alloy AA2024) involving hot working, reheating the alloy, a second hot working, solution heat treating, rapid cooling, and natural aging with process times and temperatures that overlap applicants' claimed procedure for these Al-Cu-Mg alloys. These heat treated alloys possess fracture toughness and tensile yield stress properties which overlap applicants' claimed Al alloys. See lines 42 to 68 in column 5, lines 8 to 9 in

column 6, lines 14 to 17 in column 7, and figure 3. Cho does not describe any preferred volume concentration of intermetallic compounds (e.g., Al_7Cu_2Fe and $CuMgAl_2$), but Hyatt, et al. teach that these compounds must be present in amounts less than 1.5 volume percent in order that fracture toughness of the alloy does not fall below the desired levels. See lines 50 to 65 in column 4. Hyatt, et al., defined the volume percent of these compounds for Al-Cu-Mg alloys having composition ranges which overlap the applicants' claimed alloy compositions. See claim 11 in column 13. It would have been obvious at the time of the applicants' claimed process for making an Al-Cu-Mg alloy for a person skilled in the art of aluminum alloy metallurgy to combine the disclosure of Cho in view of Hyatt, et al. and arrive at the applicants' claimed process and Al alloy. It would have been obvious for a skilled person to combine these two references because both patents are concerned with the improvement of fracture toughness <u>and</u> tensile yield strength in Al-Cu-Mg alloys by thermomechanical treatment involving hot working, solution heat treating, and homogenizing.

The following is a quotation of the first paragraph of 35 U.S.C. § 112:

> The specification shall contain a written description of the invention, and of the manner and process of making and using it, in such full, clear, concise, and exact terms as to enable any person skilled in the art to which it pertains,

> or with which it is most nearly connected, to make and use the same and shall set forth the best mode contemplated by the inventor of carrying out his invention.

The specification is objected to under 35 U.S.C. § 112, first paragraph, as failing to provide adequate written description of the invention.

One page 6 of the specification, lines 23 to 27, applicants use the wording "higher purity alloy" to describe which alloys are suitable as cladding for the Al alloy core. This wording is not a clear description of the preferred (cladding) alloy because Al alloys have a wide range of tolerable impurity elements as well as a wide concentration range for each impurity element.

Claims 7 and 29 are rejected under 35 U.S.C. § 112, first paragraph, for the reasons set forth in the objection to the specification.

Claims 7 and 29 are rejected under 35 U.S.C. § 112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which applicant regards as the invention.

Claims 7 and 29 are rejected as being vague because the wording "higher purity aluminum alloy" does not identify the Al alloys which are suitable for use as <u>typical</u> cladding alloys.

Claim 1 is rejected under 35 U.S.C. § 112, second paragraph,

as being indefinite for failing to particularly point out and distinctly claim the subject matter which applicant regards as the invention.

Claim 1 is rejected because the wording "cladding thereon of an aluminum;" in line 9 is not clear.

Claims 1, 13, 20, 22, 23, 33, 40, 41, 58, 59, 60, 61, 62, 63, and 64 are rejected under 35 U.S.C. § 112, first paragraph, as the disclosure is enabling only for claims limited to a reheating step that is performed in the range of 900 to 945°F, not temperatures greater than 945°F. Applicants state that temperature and duration of the reheat are important factors in the heat treatment of clad products. Copper can diffuse to the Al alloy cladding when high temperatures and/or prolonged heating times are used during the reheat step. See specification at page 8, lines 10 to 27, and page 9, lines 1 to 12. See M.P.E.P. §§ 706.03(n) and 706.03(z).

Claim s 24 and 28 are rejected under 35 U.S.C. § 112, fourth paragraph, as being of improper dependent form for failing to further limit the subject matter of a previous claim.

Claims 24 and 28 are rejected because they do not provide additional limitation to the hot roll temperature ranges of steps (a) and (c) in claim 23.

The following is a quotation of the first paragraph of 35 U.S.C. § 112:

> The specification shall contain a written description of the invention, and of the manner and process of making and using it, in such full, clear, concise, and exact terms as to enable any person skilled in the art to which it pertains, or with which it is most nearly connected, to make and use the same and shall set forth the best mode contemplated by the inventor of carrying out his invention.

The specification is objected to under 35 U.S.C. § 112, first paragraph, as failing to provide an adequate written description of the invention.

On page 11 of the specification, lines 15 to 17, applicants state that the Al stock steel has a fatigue crack growth rate of 10^{-4} inches per cycle, but the plot of da/dN _versus_ crack length in figure 2 for the _improved_ _product_ shows growth rates much less than 10^{-4} (approx. $6x10^{-5}$).

Claim 45 is rejected under 35 U.S.C. § 112, first paragraph, for the reasons set forth in the objection to the specification.

The specification (see page 13, lines 5 to 7) states a growth rate of $5.3x10^{-5}$ for the improved product.

Claims 58 to 64 are rejected under 35 U.S.C. § 112, first paragraph, as the disclosure is enabling only for claims limited to Al alloys with 4.0 to 4.5% Cu, 1.2 t 1.5% Mg, and 0.4 to 0.7% Mn. See page 4 of the specification, lines 9 to 12. The

specification does not teach or suggest that lower levels of Cu, Mg, and Mn should be present in these Al alloys. See M.P.E.P. §§ 706.03(n) and 706.03(z).

Claims 1 to 64 are provisionally rejected under the judicially created doctrine of obviousness-type double patenting as being unpatentable over claims 1 to 58 of copending application Serial No. 07/572,626. Although the conflicting claims are not identical, they are not patentably distinct from each other because both applications disclose similar Al-Cu-Mg alloys, similar thermo-mechanical treatments of the alloys, and similar usage of alloys in aircraft structures (including clad aluminum alloy structures).

This is a *provisional* obviousness-type double patenting rejection because the conflicting claims have not in fact been patented.

Claims 1 to 64 are provisionally rejected under the judicially created doctrine of obviousness-type double patenting as being unpatentable over claim 1 to 41 of copending application Serial No. 07/620,626. Although the conflicting claims are not identical, they are not patentably distinct from each other because both applications disclose similar Al-Cu-Mg alloys, similar thermomechanical treatments of the alloys, and similar

usage of alloys in aircraft structures (including clad aluminum alloy structures).

This is a *provisional* obviousness-type double patenting rejection because the conflicting claims have not in fact been patented.

The obviousness-type double patenting rejection is a judicially established doctrine based upon public policy and is primarily intended to prevent prolongation of the patent term by prohibiting claims in a second patent not patentably distinct from claims in a first patent. *In re Vogel*, 164 USPQ 619 (CCPA 1970). A timely filed terminal disclaimer in compliance with 37 C.F.R. § 1.321(b) would overcome an actual or provisional rejection on this ground provided the conflicting application or patent is shown to be commonly owned with this application. See 37 C.F.R. § 1.78(d).

Any inquiry concerning this communication or earlier communications from the examiner should be directed to Robert Koehler whose telephone number is (703) 308-3188.

Any inquiry of a general nature or relating to the status of this application should be directed to the Group receptionist whose telephone number is (703) 308-0661.

R. Dean

R. DEAN
PRIMARY EXAMINER
GROUP 110 - ART UNIT 111

R. Koehler:rg RGK
August 20, 1991

Exhibit 3

[redacted]

ABANDONED

ABANDONED

SERIAL NUMBER (Series of 1987)	PATENT DATE	PATENT NUMBER
07/572,625		

SERIAL NUMBER	FILING DATE	CLASS	SUBCLASS	GROUP ART UNIT	EXAMINER
07/572,625	08/27/90	148	~~12.7A~~ 693	111	~~Schwartz~~ KOEHLER

APPLICANTS: EDWARD L. COLVIN, PITTSBURGH, PA; JOCELYN I. PETIT, NEW KENSINGTON, PA; ROBERT W. WESTERLUND, BETTENDORF, IA.

CONTINUING DATA********************
VERIFIED
RKK

FOREIGN/PCT APPLICATIONS**********
VERIFIED
RKK

NOTE - DISCLAIMER
The term of this patent subsequent to ______ has been disclaimed

Foreign priority claimed ☐ yes ☒ no; 35 USC 119 conditions met ☐ yes ☒ no; Verified and Acknowledged RKK Examiner's initials	AS FILED	STATE OR COUNTRY	SHEETS DRWGS	TOTAL CLAIMS	INDEP CLAIMS	FILING FEE RECEIVED	ATTORNEY'S DOCKET NO.
		PA	4	64	24	$1,654.00	

ADDRESS: ANDREW ALEXANDER
ALUMINUM COMPANY OF AMERICA
ALCOA CENTER, PA 15069

TITLE: DAMAGE TOLERANT ALUMINUM ALLOY CLAD SHEET FOR AIRCRAFT SKIN

U.S. DEPT. of COMM.- Pat. & TM Office—PTO-436L (rev. 10-78)

PARTS OF APPLICATION FILED SEPARATELY

NOTICE OF ALLOWANCE MAILED: July 1, 1992

ISSUE FEE

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RKK
W. DEAN
PRIMARY EXAMINER
GROUP 110 - ART UNIT 111
11/01
Primary Examiner

CLAIMS ALLOWED

Total Claims	Print Claim
64	1

DRAWING

Sheets Drwg.	Figs. Drwg.	Print Fig.
4	4	1

ISSUE CLASSIFICATION

Class	Subclass
148	693

ISSUE BATCH NUMBER: E26

FORM PTO-1267 U.S. DEPT. OF COMMERCE PAT. & TM OFF.
(REV. 6-78)
DISCLAIMER LABEL

SERIAL NO.	FILING DATE
572,625	08/27/90

Terminal disclaimer has been entered and recorded under 35 U.S.C. 253 in this file by Issue Division.

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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

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PAT. & TRADEMARK OFF.

In re application of

Edward L. Colvin et al)

Serial No. 07/572,625) Group Art Unit 111

Filed August 27, 1990) Examiner R. Koehler

For Damage Tolerant Aluminum Alloy Clad Sheet for Aircraft Skin)

I hereby certify that this correspondence is being deposited with the United States Postal Service as first class mail in an envelope addressed to: Commissioner of Patent and Trademarks, Washington, D.C. 20231 on February 21, 1992.

Carl R. Lippert, Reg. No. 22375
Date of Signature: February 21, 1992

BOX NON-FEE AMENDMENT
Commissioner of Patents and Trademarks
Washington, D.C. 20231

Sir:

In response to the Office Action dated August 22, 1991, please amend the above-identified application as follows:

Please rewrite claims 1, 3, 7, 13, 14, 19-25, 29-33, 39, 40-42, 45 and 50-64 as follows:

1. (Amended) A method of producing an aluminum base alloy clad sheet product having [high] good strength levels and good levels of fracture toughness and resistance to fatigue crack growth comprising:

(a) providing a body [of] comprising an aluminum base alloy [containing 4.0] consisting essentially of about 4 to 4.5 wt.% Cu, 1.2 to 1.5 wt.% Mg, 0.4 to 0.7 wt.% Mn, 0.5 wt.% max. Fe, 0.5 wt.% max. Si, the remainder substantially aluminum, incidental elements and impurities, the body having a cladding thereon of aluminum or an aluminum alloy;

(b) hot rolling the body to a slab;

(c) heating said slab [to above 910°F to dissolve soluble constituents] within about 900° to 945°F;

(d) further hot rolling the slab [in a temperature range of 600 to 850°F to a sheet product];

(e) solution heat treating; and

(f) cooling[; and

(g) naturally aging to provide a clad sheet product having high strength and improved levels of fracture toughness and resistance to fatigue crack growth].

---

3. (Amended) The method in accordance with claim 1 wherein [the sheet product is] cold [rolled to a final sheet gauge] rolling is done after [said] hot rolling.

A3

7. (Amended) The method in accordance with claim 1 wherein the cladding [is a higher purity] contains more aluminum [alloy] than said aluminum base alloy in said body.

13. (Amended) A method of producing an aluminum base alloy clad sheet product having [high] good strength levels and good levels of fracture toughness and resistance to fatigue crack growth comprising:

A4

(a) providing a body [of] comprising an aluminum base alloy [containing] consisting essentially of about 4.1 to 4.4 wt.% Cu, 1.2 to 1.45 wt.% Mg, 0.4 to 0.6 wt.% Mn, 0.12 wt.% max. Fe, 0.1 wt.% max. Si, the remainder substantially aluminum, incidental elements and impurities, the body having a cladding thereon of essentially aluminum or an aluminum alloy;

(b) hot rolling the body to a slab [in a temperature range of 600 to 900°F];

(c) reheating said slab [to above 910°F] within about 900° to 945°F;

(d) further hot rolling the slab [in a temperature range of 600 to 900°F to a sheet product];

(e) solution heat treating for a time of less than 60 minutes [in a temperature range of 910 to 1050°F] within 910° to 945°F;

(f) rapidly cooling; and

(g) aging [to provide a clad sheet product having high strength and good levels of fracture toughness and resistance to fatigue crack growth].

14. (Amended) The method in accordance with claim [13] 1 wherein [the sheet is solution heat treated in a temperature range of 910 to 945°F] , subsequent to said cooling, a working effect is imparted substantially equivalent to stretching up to 10% at room temperature.

24 amd.

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19. (Amended) The method in accordance with claim 13 wherein after hot rolling the [sheet] **metal** is cold rolled to a cold rolled gauge in the range of 0.05 to 0.25 inch.

23

20. (Amended) A method of producing an aluminum base alloy clad sheet product having high strength levels and good levels of fracture toughness and resistance to fatigue crack growth comprising:

(a) providing a body [of] comprising an aluminum base alloy [containing 4.0] consisting essentially of about 4 to 4.5 wt.% Cu, 1.2 to 1.4 wt.% Mg, 0.4 to 0.6 wt.% Mn, 0.5 wt.% max. Fe, 0.5 wt.% max. Si, the remainder substantially aluminum, incidental elements and impurities, the body having a cladding thereon of aluminum or an aluminum alloy;

(b) hot rolling the body to a slab [in a temperature range of 600 to 900°F];

(c) heating said slab [to above 910°F] within about 900° to 945°F;

(d) hot rolling the slab [in a temperature range of 600 to 900°F to a sheet product];

(e) cold rolling to a sheet gauge having a thickness in the range of 0.05 to 0.25 inch;

(f) solution heat treating for a time of less than 15 minutes [in a temperature range of 910 to 1050°F] within 910° to 945°F;

(g) rapidly cooling; and

(h) naturally aging [to provide a clad sheet product having high strength and good levels of fracture toughness and resistance to fatigue crack growth].

21. (Amended) A method of producing an aluminum base alloy clad sheet product having [high] <u>good</u> strength and improved levels of fracture toughness and fatigue crack growth resistance comprising:

(a) providing a body [of] <u>comprising</u> an aluminum base alloy [containing] <u>consisting essentially of about</u> 4.1 to 4.4 wt.% Cu, 1.2 to 1.45 wt.% Mg, 0.4 to 0.6 wt.% Mn, 0.12 wt.% max. Fe, 0.1 wt.% max. Si, the remainder <u>substantially</u> aluminum, incidental elements and impurities, the body having a cladding thereon of aluminum <u>or an aluminum alloy</u>;

B 3 cont.

(b) hot rolling the body to a slab [in a temperature in the range of] <u>comprising rolling within about</u> 600 to 900°F;

(c) reheating said slab <u>within about</u> [to] 910 to 945°F [to dissolve soluble constituents];

(d) hot rolling the slab [in a temperature range of] <u>comprising rolling within about</u> 600 to 850°F;

(e) cold rolling to a sheet gauge product having a thickness in the range of 0.05 to 0.25 inch;

(f) solution heat treating said product for a time of less than 15 minutes [at a solution heat treating temperature in the range of 910 to 1050°F] <u>within about 910° to 945°F</u>;

(g) rapidly cooling; and

(h) naturally aging [said product to provide a clad sheet product having high strength and improved levels of fracture toughness and resistance to fatigue crack growth].

22. (Amended) A method of producing an aluminum base alloy clad sheet product having [high] good strength levels and improved levels of fracture toughness and resistance to fatigue crack growth comprising:

(a) providing a body [of] comprising an aluminum base alloy [containing] consisting essentially of about 4.1 to 4.5 wt.% Cu, 1.2 to 1.5 wt.% Mg, 0.4 to 0.6 wt.% Mn, 0.12 wt.% max. Fe, 0.1 wt.% max. Si, the remainder substantially aluminum, incidental elements and impurities, the body having a cladding thereon of an aluminum selected from AA1100, 1200, 1230, 1135, 1235, 1435, 1145, 1345, 1250, 1350, 1170, 1175, 1180, 1185, 1285, 1188, 1199 or 7072;

(b) hot rolling the body to a slab [in a temperature range of] comprising rolling within about 600 to 900°F;

(c) reheating said slab [to above] within about 910°F to 945°F [to dissolve soluble constituents];

(d) hot rolling the slab [in a temperature range of] comprising rolling within about 600 to 850°F;

(e) cold rolling to a sheet [gauge] having a thickness in the range of 0.05 to 0.25 inch;

(f) solution heat treating for a time of less than 15 minutes [in a temperature range of 910 to 1050°F] within about 910° to 945°F;

(g) rapidly cooling; and

(h) naturally aging [to provide a clad sheet product having high strength and improved levels of fracture toughness and resistance to fatigue crack growth].

23. (Amended) In a method of producing [an aluminum base alloy clad] aircraft skin wherein an aluminum alloy product is formed [to produce] in producing said aircraft skin, the improvement wherein said product is provided [as] by the method comprising:

(a) providing a body comprising an aluminum base alloy [containing 4.0] consisting essentially of about 4 to 4.5 wt.% Cu, 1.2 to 1.45 wt.% Mg, 0.4 to 0.6 wt.% Mn, 0.12 wt.% max. Fe, 0.1 wt.% max. Si, the remainder substantially aluminum, incidental elements and impurities, the [product] body having a cladding thereon of aluminum[, the product further provided in the condition resulting from:] or an aluminum alloy;

[(a)] (b) hot rolling said alloy to a slab [in a temperature range of 600 to 900°F];

[(b)] (c) heating said slab [to above 910°F to dissolve soluble constituents] within about 910° to 945°F;

[(c)] (d) further hot rolling the slab [in a temperature range of 600 to 900°F to a sheet product];

[(d)] (e) solution heat treating [the sheet product] within about 910° to 945°F; and

[(e)] (f) cooling[; and

(f) naturally aging to provide a clad sheet product having high strength and good levels of fracture toughness and resistance to fatigue crack growth].

24. (Amended) The method in accordance with claim [23] 1 wherein [the body is hot rolled in a temperature range of 600 to 900°F prior to said heating step] , subsequent to said cooling, a working effect is imparted substantially equivalent to stretching about 0.5 to 6% at room temperature.

25. (Amended) In the [The] method in accordance with claim 23 wherein the [sheet product] metal is cold rolled [to a final sheet gauge] after [said] hot rolling [step].

29. (Amended) The method in accordance with claim 23 wherein the cladding [is a higher purity] contains more aluminum [alloy] than said aluminum base alloy in said body.

33. (Amended) In a method of producing [an aluminum base alloy clad] aircraft skin wherein an aluminum alloy sheet product is [formed to produce] used in producing said aircraft skin product, the improvement wherein said sheet product is provided by a method comprising:

(a) providing a body comprising [as] an aluminum base alloy [containing] consisting essentially of about 4.1 to 4.4 wt.% Cu, 1.2 to 1.45 wt.% Mg, 0.4 to 0.6 wt.% Mn, 0.12 wt.% max. Fe, 0.1 wt.% max. Si, the remainder substantially aluminum, incidental elements and impurities, the sheet product having a cladding thereon of aluminum or aluminum alloy, [the sheet product further provided in the condition resulting from:]

[(a)] (b) hot rolling the alloy to a slab [in a temperature range of 600 to 900°F];

[(b)] (c) heating said slab [to above 910°F to dissolve soluble constituents] within about 900° to 945°F;

[(c)] (d) further hot rolling the slab [in a temperature in the range of 600 to 900°F to a sheet product];

[(d)] (e) solution heat treating [for a time of less than 15 minutes in a temperature range of 910 to 1050°F] within 910° to 945°F; and

[(e)] (f) rapidly cooling[; and

(f) naturally aging to provide a clad sheet product having high strength and good levels of fracture toughness and resistance to fatigue crack growth].

39. (Amended) The method in accordance with claim 33 wherein the [sheet] metal is cold rolled [after] subsequent to the last hot rolling step to a gauge in the range of 0.05 to 0.25 inch.

A8

40. (Amended) In a method of producing an [a damage tolerant aluminum base alloy clad] aircraft fuselage skin [product] wherein an aluminum alloy sheet product is used in making said fuselage skin, the improvement wherein said sheet product is provided [as an aluminum base alloy containing 4.0] by a method comprising:

(a) providing a body comprising an aluminum alloy consisting essentially of about 4 to 4.5 wt.% Cu, 1.2 to 1.45 wt.% Mg, 0.4 to 0.6 wt.% Mn, 0.12 wt.% max. Fe, 0.1 wt.% max. Si, the remainder substantially aluminum, incidental elements and impurities, the [product] body having a cladding thereon of AA1000 series type aluminum alloy;[, the product further provided in the condition resulting from:]

A8 cont.

[(a)] (b) hot rolling [and bonding the cladding to] said alloy [in a temperature range of 600 to 900°F] to form a slab;

[(b)] (c) heating said slab [to above 910°F] within about 900° to 945°F;

[(c)] (d) hot rolling the slab [in a temperature range of 600 to 900°F];

[(d)] (e) cold rolling to a sheet gauge having a thickness in the range of 0.05 to 0.25 inch;

[(e)] (f) solution heat treating for a time of less than 15 minutes [in a temperature range of 910 to 1050°F] within about 910° to 945°F;

[(f)] (g) rapidly cooling; and

A8 cont'd.

[(g)] <u>(h)</u> naturally aging [to provide a clad sheet product having high strength and good levels of fracture toughness and resistance to fatigue crack growth].

41. (Amended) In a method of producing an [a damage tolerant aluminum base alloy clad] aircraft wing skin product wherein an aluminum metal product is used in making said wing skin product, the improvement wherein said aluminum metal product is provided [as] by a method comprising:

(a) providing a body comprising an aluminum base alloy [containing 4.0] consisting essentially of about 4 to 4.5 wt.% Cu, 1.2 to 1.5 wt.% Mg, 0.4 to 0.6 wt.% Mn, 0.12 wt.% max. Fe, 0.1 wt.% max. Si, the remainder substantially aluminum, incidental elements and impurities, the product having a cladding thereon of essentially aluminum; [, the product further provided in the condition resulting from:]

[(a)] (b) hot rolling the alloy to a slab [in a temperature range of 600 to 900°F];

[(b)] (c) heating said slab [to above 910°F] within 900° to 945°F;

[(c)] (d) further hot rolling the slab [in a temperature range of 600 to 850°F to a sheet product];

[(d)] (e) cold rolling to a sheet gauge having a thickness in the range of 0.05 to 0.25 inch;

[(e)] (f) solution heat treating [for a time of less than 15 minutes in a temperature range of 910 to 1050°F] within about 910° to 945°F; and

[(f)] (g) rapidly cooling[; and

(g) naturally aging to provide a clad sheet product having high strength and good levels of fracture toughness and resistance to fatigue crack growth].

C 8 cont.

A8 cont'd

42. (Amended) [A damage tolerant] An aluminum base alloy clad sheet product having [high] good strength [and] with improved levels of fracture toughness and resistance to fatigue crack growth, the sheet [having] comprising a core of an aluminum base alloy [containing 4.0] consisting essentially of about 4 to 4.5 wt.% Cu, 1.2 to 1.45 wt.% Mg, 0.4 to 0.6 wt.% Mn, 0.12 wt.% max. Fe, 0.1 wt.% max. Si, the remainder substantially aluminum and incidental elements and impurities, the sheet having a minimum long transverse yield strength of 40 ksi, a minimum T-L fracture toughness K_{app} of [140] 88 ksi $\sqrt{in}$.

A9

45. (Amended) The sheet product in accordance with claim 42 wherein the product has a T-L fatigue crack growth rate [of] less than 10^{-4} inches per cycle at a [minimum] cyclic stress intensity range of 22 ksi $\sqrt{in}$.

A10

50. (Amended) The sheet product in accordance with claim 42 wherein the product is substantially recrystallized.

51. (Amended) [A damage tolerant] An aluminum base alloy clad sheet product having [high] good strength and improved levels of fracture toughness and resistance to fatigue crack growth in the solution heat treated, quenched and aged condition, the sheet [having] comprising a core of an aluminum base alloy [containing 4.0] consisting essentially of about 4 to 4.5 wt.% Cu, 1.2 to 1.5 wt.% Mg, 0.4 to 0.6 wt.% Mn, 0.12 wt.% max. Fe, 0.1 wt.% max. Si, the remainder substantially aluminum and incidental elements and impurities, the sheet having a minimum long transverse yield strength of 42 ksi, the sheet having a cladding of aluminum selected from AA1145, 1230, 1060 and 1100, the sheet having a thickness of 0.05 to 0.25 inch[,] and a minimum T-L fracture toughness K_{app} of [140] 88 ksi √in[, the core having a volume fraction of particles including Al_2CuMg and Al_2Cu less than 1.25 vol.% larger than 0.15 square µm].

52. (Amended) [A damage tolerant] An aircraft skin comprised of [a core of] an aluminum [base] alloy product comprising a core and [, the core having a] cladding [of] comprising aluminum [thereon] of the AA1000 series thereon, the [skin] aluminum alloy product having [high] good strength and improved levels of fracture toughness and resistance to fatigue crack growth, [the skin having a] said core [of] comprising an aluminum base alloy [containing 4.0] consisting essentially of about 4 to 4.5 wt.% Cu, 1.2 to 1.45 wt.% Mg, 0.4 to 0.6 wt.% Mn, 0.1 wt.% max. Fe, 0.1 wt.% max. Si, the remainder substantially aluminum and incidental elements and impurities, the [skin] aluminum alloy product having a minimum long transverse yield strength of 40 ksi[,] and a minimum T-L fracture toughness K_{app} of [140] 88 ksi √in.

53. (Amended) [A damage tolerant] An aircraft skin comprised of [a core of] an aluminum [base] alloy product comprising a core and [, the core having a] cladding [of] comprising an aluminum alloy thereon, the [skin] aluminum alloy product having [high] good strength and improved levels of fracture toughness and resistance to fatigue crack growth in the solution heat treated, quenched and naturally aged condition, the [skin having a] core [of] comprising an aluminum base alloy [containing 4.0] consisting essentially of about 4 to 4.5 wt.% Cu, 1.2 to 1.5 wt.% Mg, 0.4 to 0.6 wt.% Mn, 0.1 wt.% max. Fe, 0.1 wt.% max. Si, the remainder substantially aluminum and incidental elements and impurities, the skin having a minimum long transverse yield strength of [42] 40 ksi, the [skin having a] cladding [of] comprising an aluminum alloy selected from AA1145, 1230, 1060 and 1100, the [skin] aluminum alloy product having a thickness of 0.05 to 0.25 inch[,] and a minimum T-L fracture toughness of 140 ksi √in[, the core having a volume fraction of particles including Al_2CuMg and Al_2Cu less 1.25 vol.% larger than 0.15 square µm].

A10 cont

54. (Amended) [A damage tolerant] An aircraft fuselage skin comprised of [a core of] an aluminum [base] alloy product comprising a core and [, the core having a] cladding [of] comprising aluminum alloy thereon, the [skin] aluminum alloy product having [high] good strength and improved levels of fracture toughness and resistance to fatigue crack growth, the [skin having a] core [of] comprising an aluminum base alloy [containing 4.0] consisting essentially of about 4 to 4.5 wt.% Cu, 1.2 to 1.5 wt.% Mg, 0.4 to 0.6 wt.% Mn, 0.12 wt.% max. Fe, 0.1 wt.% max. Si, the remainder substantially aluminum and incidental elements and impurities, the [skin] aluminum alloy product having a minimum long transverse yield strength of 40 ksi, a minimum T-L fracture toughness K_{app} of [140] 88 ksi √in.

55. (Amended) [A damage tolerant] An aircraft fuselage skin comprised of [a core of] an aluminum [base] alloy product comprising a core and [, the core having a] cladding [of] comprising an aluminum alloy thereon, the [skin] aluminum alloy product having [high] good strength and improved levels of fracture toughness and resistance to fatigue crack growth in the solution heat treated, quenched and naturally aged condition, the [skin having a] core [of] comprising an aluminum base alloy [containing 4.0] consisting essentially of about 4 to 4.5 wt.% Cu, 1.2 to 1.5 wt.% Mg, 0.4 to 0.6 wt.% Mn, 0.12 wt.% max. Fe, 0.1 wt.% max. Si, the remainder substantially aluminum and incidental elements and impurities, the [skin] aluminum alloy product having a minimum T-L yield strength of [42] 40 ksi, the [skin having a] cladding selected from AA1145, 1230, 1060 and 1350, the skin having a thickness of 0.05 to 0.25 inch[,] and a minimum T-L fracture toughness K_c of [140] 88 ksi √in[, the core having a volume fraction of particles including Al_2CuMg and Al_2Cu less 1.25 vol.% larger than 0.15 square μm].

Cl. 10 cont'd.

56. (Amended) [A damage tolerant] An aircraft wing skin comprised of [a core of] an aluminum [base] alloy product comprising a core and [, the core having a] cladding [of] comprising an aluminum alloy thereon, the [skin] aluminum alloy product having [high] good strength and improved levels of fracture toughness and resistance to fatigue crack growth, the [skin having a] core [of an aluminum base alloy containing 4.0] comprising an aluminum alloy consisting essentially of about 4 to 4.5 wt.% Cu, 1.2 to 1.5 wt.% Mg, 0.4 to 0.6 wt.% Mn, 0.12 wt.% max. Fe, 0.1 wt.% max. Si, the remainder substantially aluminum and incidental elements and impurities, the [skin] aluminum alloy product having a minimum long transverse yield strength of 40 ksi[,] and a minimum T-L fracture toughness K_{app} of [140] 88 ksi $\sqrt{\text{in}}$.

57. (Amended) [A damage tolerant] <u>An</u> aircraft wing skin comprised of [a core of] <u>an</u> aluminum [base] alloy <u>product comprising a core and</u> [, the core having a] cladding [of] <u>comprising</u> an aluminum alloy thereon, the [skin] <u>aluminum alloy product</u> having [high] <u>good</u> strength and improved levels of fracture toughness and resistance to fatigue crack growth in the solution heat treated, quenched and naturally aged condition, the [skin having a] core [of] <u>comprising</u> an aluminum base alloy [containing 4.0] <u>consisting essentially of about 4</u> to 4.5 wt.% Cu, 1.2 to 1.5 wt.% Mg, 0.4 to 0.6 wt.% Mn, 0.12 wt.% max. Fe, 0.1 wt.% max. Si, the remainder <u>substantially</u> aluminum and incidental elements and impurities, [the skin having a minimum long transverse yield strength of 42 ksi,] the [skin having a] cladding [of] <u>comprising</u> an aluminum alloy selected from AA1145, 1230, 1060 and 1100, the [skin] <u>aluminum alloy product</u> having a thickness of 0.05 to 0.25 inch, <u>a minimum long transverse yield strength of 40 ksi,</u> a minimum T-L fracture toughness K_{app} of [140] <u>88</u> ksi √in[, the core having a volume fraction of particles including Al_2CuMg and Al_2Cu less 1.25 vol.% larger than 0.15 square µm].

7/10

58. (Amended) A method of producing an aluminum base alloy clad sheet product having [high] good strength levels and good levels of fracture toughness and resistance to fatigue crack growth comprising:

(a) providing a body [of] comprising an aluminum base alloy [containing] consisting essentially of about 3.8 to 4.5 wt.% Cu, 1.2 to 1.85 wt.% Mg, 0.3 to 0.78 wt.% Mn, 0.5 wt.% max. Fe, 0.5 wt.% max. Si, the remainder substantially aluminum, incidental elements and impurities, the body having a cladding thereon of an aluminum;

(b) hot rolling the body to a slab;

(c) heating said slab [to above 910°F to dissolve soluble constituents] within about 900° to 945°F;

(d) further hot rolling the slab [in a temperature range of 600 to 850°F to a sheet product];

(e) solution heat treating; and

(f) cooling[; and

(g) naturally aging to provide a clad sheet product having high strength and improved levels of fracture toughness and resistance to fatigue crack growth].

59. (Amended) A method of producing an aluminum base alloy clad sheet product having [high] good strength levels and good levels of fracture toughness and resistance to fatigue crack growth comprising:

(a) providing a body [of] comprising an aluminum base alloy [containing] consisting essentially of about 3.8 to 4.5 wt.% Cu, 1.2 to 1.85 wt.% Mg, 0.3 to 0.78 wt.% Mn, 0.5 wt.% max. Fe, 0.5 wt.% max. Si, the remainder substantially aluminum, incidental elements and impurities, the body having a cladding thereon of essentially aluminum;

A10 cont'd

(b) hot rolling the body to a slab [in a temperature range of 600 to 900°F];

(c) [re]heating said slab [to above 910°F] within about 900° to 945°F;

(d) further hot rolling the slab [in a temperature range of 600 to 900°F to a sheet product];

(e) solution heat treating for a time of less than 60 minutes [in a temperature range of 910 to 1050°F] within about 910° to 945°F;

(f) rapidly cooling; and

(g) aging [to provide a clad sheet product having high strength and good levels of fracture toughness and resistance to fatigue crack growth].

60. (Amended) A method of producing an aluminum base alloy clad sheet product having [high] good strength levels and good levels of fracture toughness and resistance to fatigue crack growth comprising:

(a) providing a body [of] comprising an aluminum base alloy [containing] consisting essentially of about 3.8 to 4.5 wt.% Cu, 1.2 to 1.85 wt.% Mg, 0.3 to 0.78 wt.% Mn, 0.5 wt.% max. Fe, 0.5 wt.% max. Si, the remainder substantially aluminum, incidental elements and impurities, the body having a cladding thereon [of] comprising an aluminum alloy;

A10 contd.

(b) hot rolling the body to a slab [in a temperature range of 600 to 900°F];

(c) heating said slab [to above 910°F] within about 900° to 945°F;

(d) further hot rolling the slab [in a temperature range of 600 to 900°F to a sheet product];

(e) cold rolling to a sheet gauge having a thickness in the range of 0.05 to 0.25 inch;

(f) solution heat treating for a time of less than 15 minutes [in a temperature range of 910 to 1050°F] within about 910° to 945°F; and

(g) rapidly cooling[; and

(h) naturally aging to provide a clad sheet product having high strength and good levels of fracture toughness and resistance to fatigue crack growth].

61. (Amended) A method of producing an aluminum base alloy clad sheet product having [high] good strength levels and improved levels of fracture toughness and resistance to fatigue crack growth comprising:

(a) providing a body [of] comprising an aluminum base alloy [containing] consisting essentially of about 3.8 to 4.5 wt.% Cu, 1.2 to 1.85 wt.% Mg, 0.3 to 0.78 wt.% Mn, 0.5 wt.% max. Fe, 0.5 wt.% max. Si, the remainder substantially aluminum, incidental elements and impurities, the body having a cladding thereon [of] comprising an aluminum selected from AA1100, 1200, 1230, 1135, 1235, 1435, 1145, 1345, 1250, 1350, 1170, 1175, 1180, 1185, 1285, 1188, 1199 or 7072;

(b) hot rolling the body to a slab [in a temperature range of 600 to 900°F];

(c) reheating said slab [to above 910°F to dissolve soluble constituents] within about 910° to 930°F;

(d) further hot rolling the slab [in a temperature range of 600 to 850°F];

(e) cold rolling to a sheet gauge having a thickness in the range of 0.05 to 0.25 inch;

(f) solution heat treating for a time of less than 15 minutes [in a temperature range of 910 to 1050°F] within about 910° to 945°F;

(g) rapidly cooling; and

A10 cont.

(h) naturally aging [to provide a clad sheet product having high strength and improved levels of fracture toughness and resistance to fatigue crack growth].

62. (Amended) In a method of producing [an aluminum base alloy clad] aircraft skin wherein an aluminum [alloy] product is [formed to produce] made into said aircraft skin, the improvement wherein said aluminum product [is provided as] is produced by a method comprising:

(a) providing a body comprising an aluminum base alloy [containing] consisting essentially of about 3.8 to 4.5 wt.% Cu, 1.2 to 1.85 wt.% Mg, 0.3 to 0.78 wt.% Mn, 0.5 wt.% max. Fe, 0.5 wt.% max. Si, the remainder substantially aluminum, incidental elements and impurities, the [product having] body further comprising a cladding thereon [of] comprising aluminum;[, the product further provided in the condition resulting from:]

A10 end.

[(a)] (b) hot rolling said [alloy] body to a slab [in a temperature range of 600 to 900°F];

[(b)] (c) heating said slab [to above] within about 910°F to 930°F [to dissolve soluble constituents];

[(c)] (d) further hot rolling the slab [in a temperature range of 600 to 900°F to a sheet product];

[(d)] (e) solution heat treating [the sheet product];

[(e)] (f) cooling; and

[(f)] (g) naturally aging [to provide a clad sheet product having high strength and good levels of fracture toughness and resistance to fatigue crack growth].

63. (Amended) In a method of producing [an aluminum base alloy clad] aircraft skin wherein an aluminum alloy sheet product is formed [to produce] in producing said aircraft skin [product], the improvement wherein said sheet product is provided [as] by the method comprising:

(a) providing a body comprising an aluminum base alloy [containing] consisting essentially of about 3.8 to 4.5 wt.% Cu, 1.2 to 1.85 wt.% Mg, 0.3 to 0.78 wt.% Mn, [0.5] 0.1 wt.% max. Fe, [0.5] 0.1 wt.% max. Si, the remainder substantially aluminum, incidental elements and impurities, the [sheet product] body having a cladding thereon [of] comprising aluminum or aluminum alloy; [, the sheet product further provided in the condition resulting from:]

A 10 cont

[(a)] (b) hot rolling the [alloy] body to a slab [in a temperature range of 600 to 900°F];

[(b)] (c) heating said slab [to above 910°F to dissolve soluble constituents] within 900° to 945°F for more than one hour;

[(c)] (d) hot rolling the slab [in a temperature in the range of 600 to 900°F to a sheet product];

[(d)] (e) solution heat treating for a time of less than [15] 60 minutes [in a temperature range of 910 to 1050°F] within 910° to 945°F;

[(e)] (f) rapidly cooling; and

[(f)] (g) naturally aging to provide a clad sheet product having high strength and good levels of fracture toughness and resistance to fatigue crack growth.

64. (Amended) In a method of producing [a damage tolerant aluminum base alloy clad] aircraft fuselage skin [product] wherein an aluminum alloy sheet product is used in producing said aircraft skin, the improvement wherein said [product] sheet is provided [as] by the method comprising:

(a) providing a body comprising an aluminum base alloy [containing] consisting essentially of about 3.8 to 4.5 wt.% Cu, 1.2 to 1.85 wt.% Mg, 0.3 to 0.78 wt.% Mn, [0.5] 0.1 wt.% max. Fe, [0.5] 0.1 wt.% max. Si, the remainder substantially aluminum, incidental elements and impurities, the [product] body having a cladding thereon of AA1000 series type aluminum alloy; [, the product further provided in the condition resulting from:]

910 Corr.

[(a)] (b) hot rolling [and bonding the cladding to said alloy in a temperature range of 600 to 900°F] to [form] a slab;

[(b)] (c) heating said slab [to above 910°F] within 900° to 945°F for more than one hour;

[(c)] (d) hot rolling the slab [in a temperature range of 600 to 900°F];

[(d)] (e) cold rolling to a sheet gauge having a thickness in the range of 0.05 to 0.25 inch;

[(e)] (f) solution heat treating for a time of less than [15] 60 minutes [in a temperature range of 910 to 1050°F] within 910° to 945°F;

[(f)] (g) rapidly cooling; and

[(g)] (h) naturally aging to provide a clad sheet product having high strength and good levels of fracture toughness and resistance to fatigue crack growth.

A 10 P.

REMARKS

The Examiner's thoroughness in examining this application is appreciated.

The claims have been amended to focus more clearly on certain features of the invention. Changes include "consisting essentially" in lieu of "containing" for alloy composition and a maximum of 945°F for the heating between hot rolling operations.

The Applicants' invention offers better combinations of strength and toughness and/or fatigue crack growth rate than the combinations achieved with the incumbent aircraft fuselage skin product 2024 alloy. This addresses a significant desire in the airplane construction field to improve over 2024 with a commercially viable large-scale producible product. The invention includes combinations of composition and process not heretofore realized in the art.

Section 102

Claims 1-41 and claims 58-64 were rejected under 35 U.S.C. 102(b) and (e) as being anticipated by Cho (Patent 4,816,087). For reasons set forth now, it is respectfully submitted that this rejection is incorrect and should be withdrawn.

The identity with Applicants' claims necessary to sustain a Section 102 rejection is lacking in Cho. The rejection assumes that Cho discloses processing steps for AA2024 or Al-Cu-Mg alloys, and it is respectfully submitted that this assumption is incorrect. Cho correctly and repeatedly characterizes his alloys as "aluminum lithium" alloys. For

instance, in Col. 3, line 30 et. seq., Cho refers to AA2091 setting forth its composition and emphasizes the importance of Li. Cho's alloys by definition contain more lithium than is allowable in alloy 2024. AA registration limits for alloy 2024 limit elements not listed to a maximum of .05% each. Cho's minimum for lithium is ten times that amount, and Cho's examples which revolve around alloy 2091 contain 2.11% lithium (more than 40 times the maximum permitted for alloy 2024). In fact, alloy 2091 has a registered minimum of 1.7% lithium which is around 34 times the maximum of 0.05% lithium permissible as an impurity according to the AA2024 registration composition limits. It is respectfully submitted that it is not correct to refer to Cho as disclosing processing for Al-Cu-Mg alloys or alloy 2024. This argument can be made only by ignoring most of what Cho discloses respecting the alloys Cho directs his process to. Applicants' present claims are clearly directed to Al-Cu-Mg alloys in contrast to Cho.

The mere fact that Cho's temperature ranges may overlap some of Applicants' temperature ranges does not support an argument for anticipation under Section 102. The ranges are clearly different and therefore there is no rejection appropriate under Section 102. Applicants respectfully emphasize that <u>all of Cho's preferred practices and the practices referred to in his example are clearly outside Applicants' presently claimed temperature ranges</u>.

Clearly the rejection under Section 102 should be withdrawn.

Section 103

Applicants' claims 1-64 were rejected under 35 U.S.C. 103 as being unpatentable over Cho in view of Hyatt et al. (Patent No. 4,294,625). It is respectfully submitted that this rejection is incorrect and should be withdrawn.

The rejection under Section 103 argues that Cho discloses a process for heat treating Al-Cu-Mg alloys (similar to alloy 2024). The preceding discussion above explains how Cho does not refer to alloy 2024 except as by way of contrast and really doesn't refer to Al-Cu-Mg alloy as part of its teaching since an indispensable and major element in Cho's alloy is lithium (see Col. 3, lines 40-50). That is why Cho calls its alloys "aluminum-lithium" alloys, again and again. Certainly, Cho contrasts his "Al-Li" alloy and his alloy product from 2024 and it is respectfully submitted that it is not appropriate to turn Cho around in arguing that Cho is processing Al-Cu-Mg alloys or alloys that "are similar" to 2024 since such defies Cho's express teachings which repeatedly refer to his alloy as a "lithium containing aluminum base alloy", that is, different from 2024. In Cho's claims, expressions like "aluminum-lithium product" (claims 1 and 6) and "aluminum-lithium alloy" (claim 13) make it clear as to what Cho is talking about. In fact, any reading of Cho's specification and claims makes it manifestly clear that Cho is referring only to an aluminum-lithium alloy and not an Al-Cu-Mg alloy in describing his processing. Accordingly, arguments seeking to equate or "similarize" alloy 2024 with Cho's alloy find no support in Cho and, it is respectfully argued, it

is incorrect to assume that support (1) for purposes of fashioning an argument respecting rejection of Applicants' claims or (2) for purposes of arguing any combination with Hyatt which does refer to Al-Cu-Mg alloys.

Further on the matter of Cho, Applicants do not agree that Cho discloses Applicants' properties. Applicants' claims recite a minimum K-apparent toughness of 88 ksi√in. It is true that Cho allows for higher fracture toughness than the Applicants' minimum but it is also true that Cho allows for considerably lower (for instance 60 ksi√in. toughness, col. 7, line 14). When Applicants refer to a minimum performance level for toughness in Applicants' claims, what Applicants are saying is that a toughness of 60 would not satisfy Applicants' minimum. When a minimum is established for a product, an airframe designer can utilize that minimum (subject to safety factor consideration) in redesigning an airplane. With respect, Applicants point out that a minimum is different than a wide range (below and above that minimum) and Applicants' claims refer to minimum property levels in reciting numbers for toughness or yield strength, and maximum levels for fatigue crack growth rates. Minimums and maximums are a lot different than "maybe's", and Applicants respectfully urge that attempting to equate broad disclosures as somehow suggesting Applicants' minimums and maximums is incorrect in framing an obviousness rejection. Still further, Cho does not refer to Applicants' improved fatigue crack growth rate properties.

Further with respect to Cho, it is again pointed out that while Cho's temperature ranges are indeed broadly stated, Cho's temperature teaching, taken as a whole, is quite incompatible with Applicants' selected temperatures. Applicants' revised claims specify a <u>maximum of 945°F</u> for Applicants' reheat temperature. Following Cho's preferred practices and examples <u>points away</u> from Applicants' present claims. <u>There is no suggestion in Cho to ignore his preferred teachings let alone do so with a different alloy</u>! It is respectfully submitted that this is a fatal flaw in framing an obviousness rejection based on Cho. There is no suggestion in Cho to use Applicants' invention; indeed Cho points in the opposite direction. Cho starts with a different alloy (an "aluminum-lithium" alloy--see all of Cho's disclosure and all of Cho's claims) and heating it at temperatures which differ from Applicants' invention. Accordingly, it is respectfully submitted that Cho is not an appropriate reference either alone or for combination with a reference such as Hyatt that does, in fact, refer to an Al-Cu-Mg alloy.

Still further, Cho's basic teaching about a duplex structure cannot be ignored in framing a rejection based on Cho alone or in combination with another reference. Why would a person who is not seeking Cho's duplex structure refer to Cho for any particular reason? Why would a person resort to Cho's processing if that person is not interested in Cho's duplex structure?

The rejection under Section 103 asserts that Hyatt's Al-Cu-Mg alloy composition ranges overlap Applicants'. It is respectfully argued that this does not form a basis for rejecting Applicants' claims. Moreover, the rejection asserted in the Office Action has not adequately explained why it would be obvious for someone to combine Cho's Al-Li alloy duplex structure processing with Hyatt's apparently conventional structure in an Al-Cu-Mg alloy. The alloys are different! The mere fact that both references seek to improve their respective different alloys by different thermal mechanical treatment alone does not suggest any combination. Any such combination of necessity requires picking this feature from one reference and combining it with that feature from the second reference with no suggestion within either reference to do so, a practice that is not appropriate in framing an obviousness rejection.

Every claim at issue, and the entire prior art, should be considered "as a whole", rather than using:

> "...selected bits and pieces from prior patents that might be modified to fit its legally incorrect interpretation of each claim as consisting of one word."

a test rejected in Panduit Corp. v. Dennison Manufacturing Co., 1 USPQ 2nd 1593, 1605 (Fed. Cir. 1987).

When extending a reference to frame a rejection under 35 USC §103, there needs to be some suggestion within the reference or within knowledge clearly present in the art for such an extension. In Ex parte Chicago Rawhide Manufacturing Co., 223 USPQ 351 (Board of Appeals, 1984), the Board reversed an

examiner's obviousness rejection based on modifications to a single reference. At page 353, the Board held:

> "The mere fact that a worker in the art could rearrange the parts of the reference device to meet the terms of the claims on appeal is not by itself sufficient to support a finding of obviousness. The prior art must provide a motivation or reason for the worker in the art, without the benefit of the appellant's specification, to make the necessary changes in the reference device. The Examiner has not presented any evidence to support the conclusion that a worker in this art would have had any motivation to make the necessary change in the [reference] device..." (Emphasis added).

What reason is shown in Cho, who says his product has toughness, to look to Hyatt's different process for a different alloy? Would Hyatt's process achieve Cho's desired duplex structure? Similarly why would Hyatt look to Cho who is talking about a different alloy? Thus, what would one find if one took Hyatt's disclosure and tried to use Cho's processing (ignoring for a moment that the person involved wasn't concerned with duplex structure)? Would that person heat to 980° as Cho recommends? It is again pointed out that the Applicants' present method claims are limited to 945°F in the reheat step and that differs substantially from Cho's teachings. Accordingly it is respectfully submitted that there is no proper basis in either Hyatt or Cho to combine the two references. It is further submitted that any such combination would point away from the Applicants' present claims unless the combination is somehow arrived at using the Applicants' specification as a road map, a procedure which has been condemned by the Court of Appeals for the Federal Circuit.

In view of the foregoing, it is respectfully argued that the rejection of Applicants' claims under 35 U.S.C. 103 is incorrect and should be withdrawn.

Section 112

The Official Action comments concerning page 6 of Applicants' specification are respectfully believed to be incorrect. The sentence objected to reads as follows:

> "Such clad products utilize a core of the aluminum base alloy of the invention and a cladding of higher purity alloy which corrosion protects the core." (Emphasis added here)

The specification goes on to elaborate:

> "The cladding includes essentially unalloyed aluminum or aluminum containing not more than 0.1 or 1% of all other elements."

This clearly points out that it is a different alloy than the core and further that it serves a corrosion protection related function. The specification goes on:

> "However, Zn can be present as in AA 7072, for example."

The specification at the top of page 7 then goes on to list several AA alloys for purposes of illustration. The Applicants respectfully argue that this paragraph taken as a whole is not inadequate. It does point out that the cladding is different than the core and it is respectfully submitted that those of ordinary skill in the art will have little trouble discerning what the Applicants are talking about. Clad aluminum products are well known in the art, for instance, refer to Cho, Col. 6, line 7.

For the foregoing reasons, it is respectfully submitted that the objection to the specification on page 6 is incorrect and should be withdrawn.

Claims 7 and 29 which were rejected under 35 U.S.C. 112 have been amended and it is respectfully submitted that these claims as amended should satisfy the objections under Section 112.

In addition, claim 1 has been amended such that, Applicants respectfully submit, the objection to claim 1, line 9, ("cladding thereon of an aluminum") should be resolved. The claim now designates that the cladding is of aluminum or an aluminum alloy.

The objection to claims 1, 13, 20, 22, 23, 33, 40, 41, 58-64 with respect to heat temperature ranges is believed to be resolved. The claims now recite heating within 900-945°F and such temperature recitation now being included in the claims should resolve the Examiner's objection.

Examiner's objections respecting claims 24 and 28 should be resolved. Claim 24 has been amended to delete the objected to language, and claim 28 should now be satisfactory because the objected to repetition has been eliminated from claim 23, the independent claim from which claims 24 and 28 depend.

The Official Action objects to page 11 of Applicants' specification in discussing fatigue crack growth rate. It is to be appreciated that lower is better when it comes to fatigue crack growth rate and it is believed that the Examiner appreciates such, judging from Examiner's comments. The figure 2

fatigue crack growth rate for the improvement which the Examiner correctly points out is well below 10^{-4} is in a specific test showing various data points. This demonstrates the kind of improvement achievable with the invention especially when it is compared with the inferior performance of 2024-T3. It is also pointed out that as the ΔK increases, the fatigue crack growth rate also increases in tests. Accordingly, it is respectfully submitted that, taken as a whole, the description is not inadequate in that the improved material could easily satisfy a material purchasing specification requirement of a fatigue crack growth rate not to exceed 10^{-4} inches per cycle at a stress intensity of 22 or a little higher.

Applicants respectfully disagree with the rejection of claim 45 under 35 U.S.C. 112. Nonetheless, in a spirit of moving prosecution of this application forward, the Applicants have amended claim 45 and it is believed that the claim as now written will not be objected to. Claim 45 now refers to a fatigue crack growth rate of less than 10^{-4} inch per cycle.

The rejection of claims 58 to 64 under 35 U.S.C. 112 is respectfully believed to be incorrect. The disclosure at page 6, line 18 et. seq. provides basis for the composition ranges in claims 58 to 64.

It is respectfully argued that the provisional rejection of the claims under the judicially created doctrine of obviousness type double patenting rejection should be set aside for the time being. Applicants do not necessarily concede the correctness of the rejection but would be willing to consider

resolving this through mutual terminal disclaiming at the appropriate time.

Again, the Examiner's thoroughness in examining this application is appreciated and it is respectfully submitted that for the reasons set forth above the present claims are all suitable for allowance and a Notice of Allowance covering all present claims is respectfully solicited.

Respectfully submitted,

Carl R. Lippert

Attorney for Applicant(s)
Reg. No. 22313

Carl R. Lippert, Esq.
Aluminum Company of America
Alcoa Center, PA 15069
Telephone 412-337-2774
Facsimile 412-337-5959
jmm;dea

Exhibit 4

[redacted]

ABANDONED

ABANDONED

SERIAL NUMBER (Series of 1987) 07/572625 | PATENT DATE | PATENT NUMBER

SERIAL NUMBER	FILING DATE	CLASS	SUBCLASS	GROUP ART UNIT	EXAMINER
07/572,625	08/27/90	148	~~12.7A~~ 693	111	~~Schumaker~~ KOEHLER

APPLICANTS

EDWARD L. COLVIN, PITTSBURGH, PA; JOCELYN I. PETIT, NEW KENSINGTON, PA; ROBERT W. WESTERLUND, BETTENDORF, IA.

CONTINUING DATA*******************
VERIFIED
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FOREIGN/PCT APPLICATIONS**********
VERIFIED
RRK

NOTE - DISCLAIMER
The term of this patent subsequent to ________ has been disclaimed

Foreign priority claimed 35 USC 119 conditions met	☐ yes ☒ no ☐ yes ☒ no	AS FILED	STATE OR COUNTRY	SHEETS DRWGS	TOTAL CLAIMS	INDEP CLAIMS	FILING FEE RECEIVED	ATTORNEY'S DOCKET NO.
Verified and Acknowledged	RRK Examiner's Initials	→	PA	4	64	24	$1,654.00	

ADDRESS

ANDREW ALEXANDER
ALUMINUM COMPANY OF AMERICA
ALCOA CENTER, PA 15069

TITLE

DAMAGE TOLERANT ALUMINUM ALLOY CLAD SHEET FOR AIRCRAFT SKIN

U.S. DEPT. of COMM.- Pat. & TM Office—PTO-436L (rev. 10-78)

PARTS OF APPLICATION FILED SEPARATELY

NOTICE OF ALLOWANCE MAILED	PREPARED FOR ISSUE		CLAIMS ALLOWED	
July 1, 1992	Robert R. Koehler Assistant Examiner	A Thompson Docket Clerk	Total Claims 64	Print Claim 1

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PRIMARY EXAMINER 11/01
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Primary Examiner

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Sheets Drwg.	Figs. Drwg.	Print Fig.
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Class	Subclass
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KOEHLER,R

ANDREW ALEXANDER
ALUMINUM COMPANY OF AMERICA
ALCOA CENTER, PA 15069

1101 9

03/20/92

☐ This application has been examined ☒ Responsive to communication filed on 2-24-92 ☒ This action is made final.

A shortened statutory period for response to this action is set to expire 3 month(s), ~~days~~ from the date of this letter.
Failure to respond within the period for response will cause the application to become abandoned. 35 U.S.C. 133

Part I THE FOLLOWING ATTACHMENT(S) ARE PART OF THIS ACTION:

1. ☐ Notice of References Cited by Examiner, PTO-892.
2. ☐ Notice re Patent Drawing, PTO-948.
3. ☐ Notice of Art Cited by Applicant, PTO-1449.
4. ☐ Notice of Informal Patent Application, Form PTO-152.
5. ☐ Information on How to Effect Drawing Changes, PTO-1474.
6. ☐ ____

Part II SUMMARY OF ACTION

1. ☒ Claims 1 to 64 are pending in the application.

   Of the above, claims ____ are withdrawn from consideration.

2. ☐ Claims ____ have been cancelled.
3. ☐ Claims ____ are allowed.
4. ☒ Claims 1 to 64 are rejected.
5. ☐ Claims ____ are objected to.
6. ☐ Claims ____ are subject to restriction or election requirement.
7. ☒ This application has been filed with informal drawings under 37 C.F.R. 1.85 which are acceptable for examination purposes.
8. ☐ Formal drawings are required in response to this Office action.
9. ☐ The corrected or substitute drawings have been received on ____. Under 37 C.F.R. 1.84 these drawings are ☐ acceptable. ☐ not acceptable (see explanation or Notice re Patent Drawing, PTO-948).
10. ☐ The proposed additional or substitute sheet(s) of drawings, filed on ____ has (have) been ☐ approved by the examiner. ☐ disapproved by the examiner (see explanation).
11. ☐ The proposed drawing correction, filed on ____, has been ☐ approved. ☐ disapproved (see explanation).
12. ☐ Acknowledgment is made of the claim for priority under U.S.C. 119. The certified copy has ☐ been received ☐ not been received ☐ been filed in parent application, serial no. ____ ; filed on ____.
13. ☐ Since this application appears to be in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under Ex parte Quayle, 1935 C.D. 11; 453 O.G. 213.
14. ☐ Other

PTOL-326 (Rev. 5-88)

Applicants' amendments to the claims are sufficient and satisfactory for overcoming the rejections under 35 USC 102, 35 USC 103, and 35 USC 112. Applicants' remarks about those rejections are persuasive in view of the amendments to the rejected claims. However, the Examiner will not withdraw the obviousness double patenting rejections involving copending applications 07/572,626 and 07/620,626.

Claims 1 to 64 are provisionally rejected under the judicially created doctrine of obviousness-type double patenting as being unpatentable over claims 1 to 28 and 30 to 58 of copending application Serial No. 07/572,626. Although the conflicting claims are not identical, they are not patentably distinct from each other because both applications claim similar Al-Cu-Mg alloys with overlapping elemental composition ranges and same alloying elements, thermomechanical treatments of the alloys with overlapping process conditions and process steps, and similar usage of the alloys in aircraft structures (including clad aluminum alloy structures).

This is a *provisional* obviousness-type double patenting rejection because the conflicting claims have not in fact been patented.

Claims 1 to 64 are provisionally rejected under the

judicially created doctrine of obviousness-type double patenting as being unpatentable over claims 1 to 41 of copending application Serial No. 07/ 620,626. Although the conflicting claims are not identical, they are not patentably distinct from each other because both applications claim Al-Cu-Mg alloys with overlapping elemental composition ranges and same alloying elements, thermomechanical treatments of the alloys with overlapping process conditions and process steps, and similar usage of the alloys in aircraft structures (including clad aluminum alloy structures).

This is a *provisional* obviousness-type double patenting rejection because the conflicting claims have not in fact been patented.

The obviousness-type double patenting rejection is a judicially established doctrine based upon public policy and is primarily intended to prevent prolongation of the patent term by prohibiting claims in a second patent not patentably distinct from claims in a first patent. *In re Vogel*, 164 USPQ 619 (CCPA 1970). A timely filed terminal disclaimer in compliance with 37 C.F.R. § 1.321(b) would overcome an actual or provisional rejection on this ground provided the conflicting application or patent is shown to be commonly owned with this application. See 37 C.F.R. § 1.78(d).

THIS ACTION IS MADE FINAL. Applicant is reminded of the extension of time policy as set forth in 37 C.F.R. § 1.136(a).

Serial No. 572,625

Art Unit 1101

A SHORTENED STATUTORY PERIOD FOR RESPONSE TO THIS FINAL ACTION IS SET TO EXPIRE THREE MONTHS FROM THE DATE OF THIS ACTION. IN THE EVENT A FIRST RESPONSE IS FILED WITHIN TWO MONTHS OF THE MAILING DATE OF THIS FINAL ACTION AND THE ADVISORY ACTION IS NOT MAILED UNTIL AFTER THE END OF THE THREE-MONTH SHORTENED STATUTORY PERIOD, THEN THE SHORTENED STATUTORY PERIOD WILL EXPIRE ON THE DATE THE ADVISORY ACTION IS MAILED, AND ANY EXTENSION FEE PURSUANT TO 37 C.F.R. § 1.136(a) WILL BE CALCULATED FROM THE MAILING DATE OF THE ADVISORY ACTION. IN NO EVENT WILL THE STATUTORY PERIOD FOR RESPONSE EXPIRE LATER THAN SIX MONTHS FROM THE DATE OF THIS FINAL ACTION.

Any inquiry concerning this communication or earlier communications from the examiner should be directed to R. Koehler whose telephone number is (703) 308-2532.

Any inquiry of a general nature or relating to the status of this application should be directed to the Group receptionist whose telephone number is (703) 308-0661.

R. Ullean

R. Koehler:rg RRK.
March 16, 1992

Exhibit 5

SERIAL NUMBER (Series of 1987) 07/572626 | PATENT DATE | PATENT NUMBER | ABANDONED

SERIAL NUMBER	FILING DATE	CLASS	SUBCLASS	GROUP ART UNIT	EXAMINER
07/572,626	08/27/90	~~428~~ 148	~~72.7A~~ 693	111	~~SCHUMA~~ KOEHLE

APPLICANTS: JOCELYN I. PETIT, NEW KENSINGTON, PA; ROBERT W. WESTERLUND, BETTENDORF, IA; EDWARD L. COLVIN, O'HARA TWP., PA.

CONTINUING DATA*******************
VERIFIED
RRK

FOREIGN/PCT APPLICATIONS**********
VERIFIED
RRK

NOTE - DISCLAIMER
The term of this patent subsequent to ______ has been disclaimed

Foreign priority claimed / 35 USC 119 conditions met / Verified and Acknowledged	AS FILED	STATE OR COUNTRY	SHEETS DRWGS	TOTAL CLAIMS	INDEP CLAIMS	FILING FEE RECEIVED	ATTORNEY'S DOCKET NO.
☐ yes ☒ no / ☐ yes ☒ no / RRK Examiner's Initials	→	PA	4	58	24	$1,582.00	

ADDRESS: ANDREW ALEXANDER
ALUMINUM COMPANY OF AMERICA
ALCOA CENTER, PA 15069

TITLE: DAMAGE TOLERANT ALUMINUM ALLOY SHEET FOR AIRCRAFT SKIN

U.S. DEPT. of COMM.- Pat. & TM Office—PTO-436L (rev. 10-

PARTS OF APPLICATION FILED SEPARATELY

NOTICE OF ALLOWANCE MAILED: July 1, 1992

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Print Claim: 1

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Figs. Drwg.: 4
Print Fig.: 1

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FORM PTO-1267 U.S. DEPT. OF COMMERCE
REV. 8-78 PAT. & TM OFF.
DISCLAIMER LABEL

SERIAL NO.	FILING DATE
572626	08/27/90

A terminal disclaimer has been entered and recorded under 35 U.S.C. 253 in this file by Patent Issue Division.

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Form PTO-436
Rev. 5/89

PATENT APPLICATION SERIAL NO. 07/572626

U.S. DEPARTMENT OF COMMERCE
PATENT AND TRADEMARK OFFICE
FEE RECORD SHEET

100 TL 08/30/90 07572626 1 101 1,582.00 CK

PTO-1556
(5/87)

Abstract of the Disclosure

Disclosed is a method of producing a sheet product having improved levels of toughness and fatigue crack growth resistance while maintaining high strength, comprising providing a body of an aluminum base alloy containing 4.0 to 4.5 wt.% Cu, 1.2 to 1.5 wt.% Mg, 0.4 to 0.6 wt.% Mn, 0.12 wt.% max. Fe, 0.05 wt.% max. Si, the remainder aluminum, incidental elements and impurities and heating a body of the alloy to above 910°F to dissolve soluble constituents. Thereafter, the body is hot rolled in the range of about 600 to 900°F, solution heat treated for a time of less than about 15 minutes at a solution heat treating temperature, and rapidly cooled and naturally aged to provide a sheet product with improved levels of fatigue crack growth resistance while maintaining high strength.

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DAMAGE TOLERANT ALUMINUM
ALLOY SHEET FOR AIRCRAFT SKIN

Background of the Invention

This invention relates to aluminum alloys suitable for use in aircraft applications and more particularly, it relates to an improved aluminum alloy and processing therefor having improved resistance to fatigue crack growth and fracture toughness and suited to use as aircraft skin.

The design of commercial aircraft requires different sets of properties for different types of structures on the airplane. In many parts, resistance to crack propagation either in the form of fracture toughness or fatigue crack growth is essential. Therefore, many significant benefits can be realized by improving fracture toughness and fatigue crack propagation.

A new material with improved toughness, for example, will have a higher level of damage tolerance. On the aircraft, this translates to improved safety for passengers and crew and weight savings in the structure which allows for improved fuel economy, longer flight range, greater payload capacity or a combination of these.

Cyclic loading occurs on a commercial jet airplane during the take off/landing when the interior of the airplane is pressurized. Typically, airplanes may see up to 100,000 pressurization cycles during their normal service lifetime. Thus, it will be noted that great benefit is derived from improved fracture toughness and resistance to fatigue crack growth, both of which are related to cyclic loading.

U.S. Patent 4,336,075 discloses the use of AA2000 type aluminum alloy for aircraft wings.

The present invention provides aluminum base alloy sheet products and a method of fabricating sheet products from a body of the alloy. Further, the invention provides aluminum alloy sheet products suitable for aircraft applications such as wing skins and aircraft fuselage panels.

Summary of the Invention

A principal object of the invention is to provide an aluminum alloy and sheet product formed therefrom, the sheet product having improved fracture toughness and resistance to fatigue crack growth while maintaining high strength properties and corrosion resistance.

A further object of the present invention is to provide aluminum alloy sheet products having improved fracture toughness and resistance to fatigue crack growth for aircraft panels.

Yet a further object of the present invention is to provide aluminum alloy sheet products and a process for producing the sheet products so as to provide improved fracture toughness and increased resistance to fatigue crack growth while still maintaining high levels of strength.

And still a further object is to provide an Al-Cu-Mg-Mn sheet product for use as aircraft panels such as wing or fuselage skins having improved resistance to fatigue crack growth while maintaining high strength levels and improved fracture toughness.

These and other objects will become apparent from a reading of the specification and claims and an inspection of the

claims appended hereto.

In accordance with these object, there is provided a method of producing a sheet product having improved levels of toughness and fatigue crack growth resistance while maintaining high strength, the method comprising providing a body of an aluminum base alloy containing 4.15 to 4.5 wt.% Cu, 1.2 to 1.45 wt.% Mg, 0.4 to 0.7 wt.% Mn, 0.1 wt.% max. Fe, 0.1 wt.% max. Si, the remainder aluminum, incidental elements and impurities. The method further comprises heating a body of the alloy to above 900°F to dissolve soluble constituents. Thereafter, the body is hot rolled in the range of about 600 to 900°F, solution heat treated for a time of less than about 15 minutes, for example, at the solution heat treating temperature, then rapidly cooled and naturally aged to provide a sheet product with improved levels of fatigue crack growth resistance and fracture toughness while maintaining high strength levels.

Brief Description of the Drawings

Figure 1 shows fracture toughness plotted against yield strength of improved material processed in accordance with the invention.

Figure 2 is a graph showing fatigue crack growth rate plotted against crack length for Aluminum Association alloy 2024 in the solution heat treated, cold worked and naturally aged T3 temper (AA2024-T3) and the improved product in accordance with the invention.

Figure 3 is a differential calorimetry curve of 2024-T3.

Figure 4 is a differential calorimetry curve of an

aluminum alloy product in accordance with the invention.

Detailed Description of the Preferred Embodiments

As noted, the alloy of the present invention comprises 4.0 to 4.5 wt.% Cu, 1.2 to 1.5 wt.% Mg, 0.4 to 0.7 wt.% Mn, 0.02 to 0.5 wt.% Fe, 0.001 to 0.5 wt.% Si, the balance aluminum, incidental elements and impurities. Impurities are preferably limited to 0.05% each and the combination of impurities preferably should not exceed 0.15%. The sum total of incidental elements and impurities preferably does not exceed 0.45%.

A preferred alloy would contain, 4.1 to 4.4 wt.% Cu, 1.2 to 1.45 wt.% Mg, 0.4 to 0.6 wt.% Mn, 0.1 wt.% max. Fe, 0.1 wt.% max. Si, the balance aluminum, incidental elements and impurities. Elements such as Zn preferably have a maximum of 0.2 wt.% and Cr 0.2 wt.% and 0.5 wt.% Zr, with a range for Zr being 0.05 to 0.25 wt.%, if it desired to make an unrecrystallized product. By unrecrystallized is meant that no more than 20 vol.% of the product is recrystallized. A typical alloy composition would contain about 4.25 wt.% Cu, 1.35 wt.% Mg, 0.5 wt.% Mn, 0.12 wt.% max. Fe and 0.1 wt.% max. Si with Fe plus Si not totaling more than 0.20 and preferbly not more than 0.15.

Mn contributes to or aids in grain size control during operations that cause the metal to recrystallize. Very large grains are detrimental to properties such as fracture toughness, formability and corrosion resistance.

Fe and Si levels are kept low to limit formation of the constituent phases Al_7Cu_2Fe and Mg_2Si which are detrimental to fracture toughness and fatigue crack growth resistance. These

phases have low solubility in Al-alloy and once formed cannot be eliminated by thermal treatments. Formation of Al_7Cu_2Fe and Mg_2Si phases can also lower the strength of the product because their formation reduces the amount of Cu and Mg available to form strengthening precipitates. Constituents such as Al_7Cu_2Fe and Mg_2Si are particularly important to avoid because they cannot be dissolved; thus, iron is kept to a very low level to avoid such constituents. That is, a decrease in Fe and Si increases toughness and resistance to fatigue crack growth. Thus, in the present invention, it is preferred to control Fe to below 0.10 wt.% and Si below 0.10 wt.%.

Cu and Mg must be carefully controlled to maintain good strength while providing the benefits in toughness and fatigue. The Cu and Mg levels must be low enough to allow for dissolution of the slightly soluble Al_2CuMg and Al_2Cu constituent phases during high temperature processing yet high enough to maximize the amount of free Cu and Mg available to form the strengthening precipitate phases. This leaves a very narrow range of Cu and Mg compositions which will produce the desired properties in the final product.

The following equations may be used to estimate the free Cu and free Mg, i.e., the amount of Cu and Mg that is available to form strengthening phases.

$$Cu_{Free}=Cu_{Total}-2.28Fe-0.74(Mn-0.2)$$

$$Mg_{Free}=Mg_{Total}-1.73(Si-0.05)$$

As well as providing the alloy product with controlled amounts of alloying elements as described herein, it is preferred

that the alloy be prepared according to specific method steps in order to provide the most desirable characteristics of both strength, fracture toughness, corrosion resistance and resistance to fatigue crack growth as required, for example, for use as aircraft skins or panels. The alloy as described herein can be provided as an ingot or slab for fabrication into a suitable wrought product by casting techniques currently employed in the art for cast products with continuous casting being preferred. Slabs resulting from belt casters or roll casters also may be used.

In a broader aspect of the invention, the alloy can comprise 3.8 to 4.5 wt.% Cu, 1.2 to 1.85 wt.% Mg, 0.3 to 0.78 wt.% Mn, 0.5 wt.% max. Fe, 0.5 wt.% Si, the balance aluminum, incidental elements and impurities.

The alloy stock may be homogenized prior to hot working or it may be heated and directly hot rolled. If homogenization is used, it may be carried out at a metal temperature in the range of 910 or 920°F to 960 or 1000°F for a period of time of at least 1 hour to dissolve soluble elements and to homogenize the internal structure of the metal. A preferred time period is about 4 hours or more in the homogenization temperature range. Normally, the soak time at the homogenizing temperature does not have to extend for more than 8 hours, however, longer times are not normally detrimental. 4 to 6 hours at the homogenization temperature has been found to be quite suitable. A typical homogenization temperature is 920°F.

For purposes of the present invention, it is preferred

to hot roll the ingot without homogenizing. Thus, the ingot is hot worked or hot rolled to provide an intermediate gauge product. Hot rolling is performed wherein the starting temperature for rolling is in the range of 600 to 900°F. When the use of the alloy is for aircraft wing skins or fuselage skins, for example, the hot rolling is performed to provide an intermediate product having a thickness of about 3 to 8 inches.

After hot rolling, the intermediate gauge product is subjected to a reheating step. It is this reheating step which is so important to the present invention, particularly with respect to minimizing or avoiding soluble constituent or secondary phase particles and their adverse effect on fatigue crack growth resistance and fracture toughness. Thus, in the reheating step, the intermediate gauge product is heated to a temperature of at least 900 or 920°F, e.g., above the solvus temperature of secondary phase particles, to dissolve soluble constituents that remain from casting or may have precipitated during the hot rolling. Such constituent particles include Al_2CuMg, Al_2Cu, for example. The reheating has the effect of putting most of the Cu and Mg into solid solution. The heating can be in the range of 900 to 945°F with a preferred range being 900 or 910 to 930°F. For purposes of reheating, the intermediate gauge product can be held for about 1 to 40 hours when the metal is in the temperature range or above the solvus temperature for the soluble constituents. Preferably, times at metal temperature are in the range of 4 to 24 hours. It is important that the reheat is carefully controlled within the parameters set forth.

If the reheating operation is lower than 900°F, for example, 850°F, this can leave large volumes of coarse undissolved Al_2CuMg and Al_2Cu particles, for example, which particles can have an adverse effect on the fatigue crack growth resistance in the final product. In fact, if the reheat is below the solvus temperature, these particles can even grow in size. It is the presence of such constituent particles which can limit crack propagation resistance in the final sheet product.

After the reheat, the intermediate product is subjected to a second hot rolling operation. The second hot rolling operation is performed in the temperature range of about 500 to 900°F, preferably 600 to 850°F. The hot rolling may be performed to a final gauge, e.g., 0.25 inch or less. Alternatively, the hot rolling step can be performed to provide a second intermediate product having a thickness in the range of 0.1 to 0.3 inch. Thereafter, the second intermediate product can be cold rolled to a final gauge of 0.25 inch or less, typically in the range of 0.05 to 0.20 inch, to produce a substantially recrystallized product. An intermediate anneal may be used before cold rolling, if desired.

After cold rolling, the sheet product is then subjected to a solution heat treatment in the range of 910 to 945°F. It is important that the solution heat treatment be carefully controlled in duration. Thus, the solution heat treatment can be accomplished in 5 minutes or even less when the metal has reached the solution temperature. The time can be extended to 15 minutes or even 60 minutes.

Solution heat treatment in accordance with the present invention may be performed on a continuous basis. Basically, solution effects can occur fairly rapidly. In continuous treating, the sheet is passed continuously as a single web through an elongated furnace which greatly increases the heat-up rate. Long solution heat treat times may be used to dissolve the soluble constituents such as Al_2CuMg and Al_2Cu. Accordingly, the inventors contemplate solution heat treating in as little as about 10 minutes, or less, for instance about 0.5 to 4 minutes. As a further aid to achieving a short heat-up time, a furnace temperature or a furnace zone temperature significantly above the desired metal temperatures provides a greater temperature head useful to speed heat-up times.

After solution heat treatment, it is important that the metal be rapidly cooled to prevent or minimize the uncontrolled precipitation of secondary phases, e.g., Al_2CuMg and Al_2Cu. Thus, it is preferred in the practice of the invention that the quench rate be at least 100°F/sec from solution temperature to a temperature of 350°F or lower. A preferred quench rate is at least 300°F/sec in the temperature range of 925°F or more to 350°F or less. Suitable rates can be achieved with the use of water, e.g., water immersion or water jets. Further, air or air jets may be employed. Preferably, the quenching takes place on a continuous basis. The sheet may be cold worked, for example, by

stretching up to 10% of its original length. Typically, cold working or its equivalent which produces an effect similar to stretching, may be employed in the range of 0.5% to 6% of the products' original length.

After rapidly quenching, the sheet product is naturally aged. By natural aging is meant to include aging at temperatures up to 175°F.

Conforming to these controls greatly aids the production of sheet stock having high yield strength, improved levels of fracture toughness, increased resistance to fatigue crack growth and high resistance to corrosion, particularly using the alloy composition of the invention. That is, sheet can be produced having a minimum long transverse yield strength of 40 or 42 ksi, suitably minimum 44, 46 or 48 ksi, and a minimum fracture toughness of 140, 145 or 150 ksi √in. Also, the sheet has a fatigue crack growth rate of 10^{-4} inches per cycle at a minimum cyclic stress intensity range of 22 ksi √in.

Sheet fabricated in accordance with the invention has the advantage of maintaining relatively high yield strength, e.g., about 47 ksi, while increasing fracture toughness to about 150 to 165 ksi √in. Fracture toughness of the product in terms of measurements stated as K apparent (K app) using 16 inch wide panel can range from 88 or 90 to 100 ksi √in. As shown in Figure 2, the new product has considerably better resistance to fatigue crack propagation than existing fuselage skin alloys in tests conducted using a constant cyclic stress intensity factor range of 22 ksi√in. This cyclic stress intensity factor range is

important for the damage tolerant design of transport airplanes such as commercial airliners.

Sheet material of the invention is characterized by a substantial absence of secondary phase particles, e.g., Al_7Cu_2Fe, $Al_6(Fe, Mn)$ Al_2CuMg and Al_2Cu particles. That is, sheet material of the invention has generally less than 1.25 vol.% of such particles larger than 0.15 square μm as measured by optical image analysis through a cross section of the product.

That is, sheet material of the invention generally has a 500 to 530°C differential scanning calorimetry peak of less than 1.0 cal/gram. Figures 3 and 4 show a comparison between the new product and 2024-T3 which is the current material of choice for the fuselage skins of commercial jet aircraft.

<u>Example</u>

A 16 x 60 inch ingot having the composition 4.28% Cu, 1.38% Mg, 0.50% Mn, 0.07% Fe, 0.05% Si, balance Al was clad with AA1145 then heated to approximately 875°F and hot rolled to a slab gauge of 4.5 inches. The slab was then heated to a temperature above 910°F for 17 hours and hot rolled to a gauge of 0.176 inch. The metal was cold rolled to a final gauge of 0.100 inch before solution heat treating for 10 minutes at 925°F and stretching 1 to 3%. The sheet was aged for 3 weeks at room temperature.

For comparison, 2024-T3, which is currently used for the fuselage skins of commercial jet airliners, having the composition 4.6% Cu, 1.5% Mg, 0.6% Mn, 0.2% Fe, 0.2% Si, balance Al, was processed the same except it was not subjected to

reheating at 910°F.

The product of the invention had a 16% higher plane stress fracture toughness (K_C=156.5 ksi√in average of new product data of Fig. 1 versus 134.7 ksi√in average of highest two points of 2024 T-3 data of Fig. 1) and at a cyclic stress intensity range of 22 ksi√in the cracks grew 44% slower (da/dN=5.3×10^{-5} in/cycle versus 9.52×10^{-5} in/cycle) as shown in the table below. One possible explanation of the metallurgical causes of the improvement can be seen in Figures 3 and 4 which show differential scanning calorimetry curves. The size of the sharp peak that occurs in the temperature range of 500 to 530°C (Fig. 3) is indicative of the amount of constituent phase or phases such as Al_2CuMg and Al_2Cu present. These phases contribute to the lowering of fracture toughness and resistance to fatigue crack growth. The new product (Fig. 4) has a much smaller peak indicating that the volume fraction of such constituent has been significantly reduced in accordance with the present invention.

The volume fraction of total large constituent phase particles (including Fe and Si bearing particles), e.g., larger than 0.15 square µm, was much smaller for the new product than for the conventionally treated 2024-T3. In twelve measurements, the new product volume fraction ranged from 0.756% to 1.056%. In twelve measurements, the conventionally treated 2024-T3 constituent volume fraction ranged from 1.429% to 2.185%.

Fatigue Crack Propagation at
Different Cyclic Stress Intensity Ranges

Sample	ΔK	da/dN
New Product	10	6.70×10^{-6}
	22	5.30×10^{-5}
	30	1.34×10^{-4}
2024-T3	10	7.91×10^{-6}
	22	9.52×10^{-5}
	30	3.71×10^{-4}

ΔK=Cyclic Stress Intensity Factor Range
da/dN=Length of crack growth during one load/unload cycle
Test performed with a R-ratio (min. load/max. load) equal to 0.33.

Fracture toughness was measured using a 16-inch wide, 44-inch long panel. All values given were taken in the T-L orientation which means that the applied load was parallel to the transverse direction of the sheet and the crack propagated parallel to the longitudinal direction of the sheet. Fatigue crack growth resistance was measured as the length a crack propagates during each cycle at a given stress intensity range. The measurements were made with an R-ratio of 0.33 in the T-L orientation. It is readily seen that as the stress intensity factor increases, the extent of the improvement becomes more prominent.

Having thus described the invention, what is claimed is:

1. A method of producing an aluminum base alloy sheet product having high strength levels and good levels of fracture toughness and resistance to fatigue crack growth comprising:

Sub a1

(a) providing a body of an aluminum base alloy containing 4.0 to 4.5 wt.% Cu, 1.2 to 1.5 wt.% Mg, 0.4 to 0.7 wt.% Mn, 0.5 wt.% max. Fe, 0.5 wt.% max. Si, the remainder aluminum, incidental elements and impurities;

(b) hot rolling the body to a slab;

(c) heating said slab to above 910°F to dissolve soluble constituents;

(d) hot rolling the slab in a temperature range of 600 to 850°F to a sheet product;

(e) solution heat treating;

(f) cooling; and

(g) naturally aging to provide a sheet product having high strength and improved levels of fracture toughness and resistance to fatigue crack growth.

2. The method in accordance with claim 1 wherein the body is hot rolled in a temperature range of 600 to 900°F prior to said heating.

Sub a2

3. The method in accordance with claim 1 wherein the sheet product is cold rolled to a final sheet gauge after said hot rolling.

4. The method in accordance with claim 1 wherein the sheet product has a gauge of 0.05 to 0.25 inch.

5. The method in accordance with claim 1 wherein the sheet product has a gauge of 0.05 to 0.15 inch.

6. The method in accordance with claim 1 wherein hot rolling is in a temperature range of 600 to 900°F.

7. The method in accordance with claim 1 wherein Cu is 4.1 to 4.5 wt.%.

8. The method in accordance with claim 1 wherein Mg is 1.2 to 1.4 wt.%.

9. The method in accordance with claim 1 wherein Fe is 0.12 wt.% max.

10. The method in accordance with claim 1 wherein Si is 0.1 wt.% max.

11. A method of producing an aluminum base alloy sheet product having high strength levels and good levels of fracture toughness and resistance to fatigue crack growth comprising:

(a) providing a body of an aluminum base alloy containing 4.1 to 4.4 wt.% Cu, 1.2 to 1.45 wt.% Mg, 0.4 to 0.6 wt.% Mn, 0.12 wt.% max. Fe, 0.1 wt.% max. Si, the remainder aluminum, incidental elements and impurities;

(b) hot rolling the body to a slab in a temperature range of 600 to 900°F;

(c) reheating said slab to above 910°F;

(d) hot rolling the slab in a temperature range of 600 to 900°F to a sheet product;

(e) solution heat treating for a time of less than 60 minutes in a temperature range of 910 to 1050°F;

(f) rapidly cooling; and

(g) aging to provide a sheet product having high strength and good levels of fracture toughness and resistance to fatigue crack growth.

12. The method in accordance with claim 11 wherein the sheet is solution heat treated in a temperature range of 910 to 945°F.

13. The method in accordance with claim 11 wherein the sheet is solution heat treated for less than 15 minutes.

14. The method in accordance with claim 11 wherein the sheet is cold water quenched.

15. The method in accordance with claim 11 wherein the sheet is naturally aged.

16. The method in accordance with claim 11 wherein after hot rolling the sheet is cold rolled to a cold rolled gauge in the range of 0.05 to 0.25 inch.

17. A method of producing an aluminum base alloy sheet product having high strength levels and good levels of fracture toughness and resistance to fatigue crack growth comprising:

(a) providing a body of an aluminum base alloy containing 4.0 to 4.5 wt.% Cu, 1.2 to 1.4 wt.% Mg, 0.4 to 0.6 wt.% Mn, 0.5 wt.% max. Fe, 0.5 wt.% max. Si, the remainder aluminum, incidental elements and impurities;

(b) hot rolling the body to a slab in a temperature range of 600 to 900°F;

(c) heating said slab to above 910°F;

(d) hot rolling the slab in a temperature range of 600 to 900°F to a sheet product;

(e) cold rolling to a sheet gauge having a thickness in the range of 0.05 to 0.25 inch;

(f) solution heat treating for a time of less than 15 minutes in a temperature range of 910 to 1050°F;

(g) rapidly cooling; and

(h) naturally aging to provide a sheet product having high strength and good levels of fracture toughness and resistance to fatigue crack growth.

18. A method of producing an aluminum base alloy sheet product having high strength and improved levels of fracture toughness and fatigue crack growth resistance comprising:

(a) providing a body of an aluminum base alloy containing 4.1 to 4.4 wt.% Cu, 1.2 to 1.45 wt.% Mg, 0.4 to 0.6 wt.% Mn, 0.12 wt.% max. Fe, 0.1 wt.% max. Si, the remainder aluminum, incidental elements and impurities;

(b) hot rolling the body to a slab in a temperature in the range of 600 to 900°F;

(c) reheating said slab to 910 to 945°F to dissolve soluble constituents;

(d) hot rolling the slab in a temperature range of 600 to 850°F;

(e) cold rolling to a sheet gauge product having a thickness in the range of 0.05 to 0.25 inch;

(f) solution heat treating said product for a time of less than 15 minutes at a solution heat treating temperature in the range of 910 to 1050°F;

(g) rapidly cooling; and

(h) naturally aging said product to provide a sheet product having high strength and improved levels of fracture toughness and resistance to fatigue crack growth.

19. A method of producing an aluminum base alloy sheet product having high strength levels and improved levels of fracture toughness and resistance to fatigue crack growth comprising:

(a) providing a body of an aluminum base alloy containing 4.1 to 4.5 wt.% Cu, 1.2 to 1.5 wt.% Mg, 0.4 to 0.6 wt.% Mn, 0.12 wt.% max. Fe, 0.1 wt.% max. Si, the remainder aluminum, incidental elements and impurities;

(b) hot rolling the body to a slab in a temperature range of 600 to 900°F;

(c) reheating said slab to above 910°F to dissolve soluble constituents;

(d) hot rolling the slab in a temperature range of 600 to 850°F;

(e) cold rolling to a sheet gauge having a thickness in the range of 0.05 to 0.25 inch;

(f) solution heat treating for a time of less than 15 minutes in a temperature range of 910 to 1050°F;

(g) rapidly cooling; and

(h) naturally aging to provide a sheet product having high strength and improved levels of fracture toughness and resistance to fatigue crack growth.

Sub A7

20. In a method of producing an aluminum base alloy aircraft skin wherein an aluminum alloy product is formed to produce said aircraft skin, the improvement wherein said product is provided as an aluminum base alloy containing 4.0 to 4.5 wt.% Cu, 1.2 to 1.45 wt.% Mg, 0.4 to 0.6 wt.% Mn, 0.12 wt.% max. Fe, 0.1 wt.% max. Si, the remainder aluminum, incidental elements and impurities, the product further provided in the condition resulting from:

(a) hot rolling said alloy to a slab in a temperature range of 600 to 900°F;

(b) heating said slab to above 910°F to dissolve soluble constituents;

(c) hot rolling the slab in a temperature range of 600 to 900°F to a sheet product;

(d) solution heat treating the sheet product;

(e) cooling; and

(f) naturally aging to provide a sheet product having high strength and good levels of fracture toughness and resistance to fatigue crack growth.

21. The method in accordance with claim 20 wherein the body is hot rolled in a temperature range of 600 to 900°F prior to said heating step.

22. The method in accordance with claim 20 wherein the sheet product is cold rolled to a final sheet gauge after said hot rolling step.

23. The method in accordance with claim 20 wherein the sheet product has a gauge of 0.05 to 0.25 inch.

24. The method in accordance with claim 20 wherein the sheet product has a gauge of 0.05 to 0.15 inch.

25. The method in accordance with claim 20 wherein hot rolling is in a temperature range of 600 to 900°F.

26. The method in accordance with claim 20 wherein Cu is 4.1 to 4.4 wt.%.

27. The method in accordance with claim 20 wherein Mg is 1.2 to 1.4 wt.%.

28. In a method of producing an aluminum base alloy aircraft skin wherein an aluminum alloy sheet product is formed to produce said aircraft skin product, the improvement wherein said sheet product is provided as an aluminum base alloy containing 4.1 to 4.4 wt.% Cu, 1.2 to 1.45 wt.% Mg, 0.4 to 0.6 wt.% Mn, 0.12 wt.% max. Fe, 0.1 wt.% max. Si, the remainder aluminum, incidental elements and impurities, the sheet product further provided in the condition resulting from:

(a) hot rolling the alloy to a slab in a temperature range of 600 to 900°F;

(b) heating said slab to above 910°F to dissolve soluble constituents;

(c) hot rolling the slab in a temperature in the range of 600 to 900°F to a sheet product;

(d) solution heat treating for a time of less than 15 minutes in a temperature range of 910 to 1050°F;

(e) rapidly cooling; and

(f) naturally aging to provide a sheet product having high strength and good levels of fracture toughness and resistance to fatigue crack growth.

29. The method in accordance with claim 28 wherein the sheet is solution heat treated in a temperature range of 910 to 945°F.

29 ~~30~~. The method in accordance with claim 28 ~~28~~ wherein the sheet is solution heat treated for less than 15 minutes.

30 ~~31~~. The method in accordance with claim 28 wherein the sheet is cold water quenched.

31 ~~32~~. The method in accordance with claim 28 wherein the sheet is naturally aged.

32 ~~33~~. The method in accordance with claim 28 wherein the sheet is cold rolled after the last hot rolling step to a gauge in the range of 0.05 to 0.25 inch.

34. In a method of producing a damage tolerant aluminum base alloy aircraft fuselage skin product, the improvement wherein said product is provided as an aluminum base alloy containing 4.0 to 4.5 wt.% Cu, 1.2 to 1.45 wt.% Mg, 0.4 to 0.6 wt.% Mn, 0.12 wt.% max. Fe, 0.1 wt.% max. Si, the remainder aluminum, incidental elements and impurities, the product further provided in the condition resulting from:

(a) hot rolling said alloy in a temperature range of 600 to 900°F to form a slab;

(b) heating said slab to above 910°F;

(c) hot rolling the slab in a temperature range of 600 to 900°F;

(d) cold rolling to a sheet gauge having a thickness in the range of 0.05 to 0.25 inch;

(e) solution heat treating for a time of less than 15 minutes in a temperature range of 910 to 1050°F;

(f) rapidly cooling; and

(g) naturally aging to provide a sheet product having high strength and good levels of fracture toughness and resistance to fatigue crack growth.

Sub A7

35. In a method of producing a damage tolerant aluminum base alloy aircraft wing skin product, the improvement wherein said product is provided as an aluminum base alloy containing 4.0 to 4.5 wt.% Cu, 1.2 to 1.5 wt.% Mg, 0.4 to 0.6 wt.% Mn, 0.12 wt.% max. Fe, 0.1 wt.% max. Si, the remainder aluminum, incidental elements and impurities, the product further provided in the condition resulting from:

(a) hot rolling the alloy to a slab in a temperature range of 600 to 900°F;

(b) heating said slab to above 910°F;

(c) hot rolling the slab in a temperature range of 600 to 850°F to a sheet product;

(d) cold rolling to a sheet gauge having a thickness in the range of 0.05 to 0.25 inch;

(e) solution heat treating for a time of less than 15 minutes in a temperature range of 910 to 1050°F; and

(f) rapidly cooling; and

(g) naturally aging to provide a sheet product having high strength and good levels of fracture toughness and resistance to fatigue crack growth.

sub A7

36. A damage tolerant aluminum base alloy sheet product having high strength and improved levels of fracture toughness and resistance to fatigue crack growth, the sheet comprised of an aluminum base alloy containing 4.0 to 4.5 wt.% Cu, 1.2 to 1.45 wt.% Mg, 0.4 to 0.6 wt.% Mn, 0.12 wt.% max. Fe, 0.1 wt.% max. Si, the remainder aluminum and incidental elements and impurities, the sheet having a minimum long transverse yield strength of 40 ksi, a minimum T-L fracture of 140 ksi √in.

36 ~~37~~. The sheet product in accordance with claim 35 ~~36~~ wherein the product has a minimum long transverse yield strength of 44 ksi.

38. The sheet product in accordance with claim 35 ~~36~~ wherein the product has a minimum T-L fracture toughness of 144 ksi √in.

sub A8

39. The sheet product in accordance with claim 36 wherein the product has a T-L fatigue crack growth rate of 10^{-4} inches per cycle at a minimum cyclic stress intensity range of 22 ksi √in.

39 ~~40~~. The sheet product in accordance with claim 35 ~~36~~ wherein the product has a volume fraction of particles including Al_2CuMg and Al_2Cu less than 1.25 vol.% larger than 0.15 square µm.

40 ~~41~~. The sheet product in accordance with claim 35 ~~36~~ wherein the product has a volume fraction of particles including Al_2CuMg and Al_2Cu less than 1 vol.% larger than 0.15 square μm.

41 ~~42~~. The sheet product in accordance with claim 35 ~~36~~ wherein the product has a thickness of 0.05 to 0.25 inch.

42 ~~43~~. The sheet product in accordance with claim 35 ~~36~~ wherein the product is solution heat treated, quenched and naturally aged.

43 ~~44~~. The sheet product in accordance with claim 35 ~~36~~ wherein the product is recrystallized.

45. A damage tolerant aluminum base alloy sheet product having high strength and improved levels of fracture toughness and resistance to fatigue crack growth in the solution heat treated, quenched and aged condition, the sheet comprised of an aluminum base alloy containing 4.0 to 4.5 wt.% Cu, 1.2 to 1.5 wt.% Mg, 0.4 to 0.6 wt.% Mn, 0.12 wt.% max. Fe, 0.1 wt.% max. Si, the remainder aluminum and incidental elements and impurities, the sheet having a minimum long transverse yield strength of 42 ksi, the sheet having a thickness of 0.05 to 0.25 inch, a minimum T-L fracture toughness of 140 ksi √in, the sheet having a volume fraction of particles including Al_2CuMg and Al_2Cu less than 1.25 vol.% larger than 0.15 square μm.

46. A damage tolerant aircraft skin comprised of an aluminum base alloy, the skin having high strength and improved levels of fracture toughness and resistance to fatigue crack growth, the skin comprised of an aluminum base alloy containing 4.0 to 4.5 wt.% Cu, 1.2 to 1.45 wt.% Mg, 0.4 to 0.6 wt.% Mn, 0.1 wt.% max. Fe, 0.1 wt.% max. Si, the remainder aluminum and incidental elements and impurities, the skin having a minimum long transverse yield strength of 40 ksi, a minimum T-L fracture toughness of 140 ksi √in.

47. A damage tolerant aircraft skin comprised of an aluminum base alloy, the skin having high strength and improved levels of fracture toughness and resistance to fatigue crack growth in the solution heat treated, quenched and naturally aged condition, the skin comprised of an aluminum base alloy containing 4.0 to 4.5 wt.% Cu, 1.2 to 1.5 wt.% Mg, 0.4 to 0.6 wt.% Mn, 0.1 wt.% max. Fe, 0.1 wt.% max. Si, the remainder aluminum and incidental elements and impurities, the skin having a minimum long transverse yield strength of 42 ksi, the skin having a thickness of 0.05 to 0.25 inch, a minimum T-L fracture toughness of 140 ksi √in, the skin having a volume fraction of particles including Al_2CuMg and Al_2Cu less 1.25 vol.% larger than 0.15 square μm.

48. A damage tolerant aircraft fuselage skin comprised of an aluminum base alloy, the skin having high strength and improved levels of fracture toughness and resistance to fatigue crack growth, the skin comprised of an aluminum base alloy containing 4.0 to 4.5 wt.% Cu, 1.2 to 1.5 wt.% Mg, 0.4 to 0.6 wt.% Mn, 0.12 wt.% max. Fe, 0.1 wt.% max. Si, the remainder aluminum and incidental elements and impurities, the skin having a minimum long transverse yield strength of 40 ksi, a minimum T-L fracture toughness of 140 ksi √in.

49. A damage tolerant aircraft fuselage skin comprised of an aluminum base alloy, the skin having high strength and improved levels of fracture toughness and resistance to fatigue crack growth in the solution heat treated, quenched and naturally aged condition, the skin comprised of an aluminum base alloy containing 4.0 to 4.5 wt.% Cu, 1.2 to 1.5 wt.% Mg, 0.4 to 0.6 wt.% Mn, 0.12 wt.% max. Fe, 0.1 wt.% max. Si, the remainder aluminum and incidental elements and impurities, the skin having a minimum T-L yield strength of 42 ksi, the skin having a thickness of 0.05 to 0.25 inch, a minimum T-L fracture toughness of 140 ksi √in, the skin having a volume fraction of particles including Al_2CuMg and Al_2Cu less 1.25 vol.% larger than 0.15 square μm.

50. A damage tolerant aircraft wing skin comprised of an aluminum base alloy, the skin having high strength and improved levels of fracture toughness and resistance to fatigue crack growth, the skin comprised of an aluminum base alloy containing 4.0 to 4.5 wt.% Cu, 1.2 to 1.5 wt.% Mg, 0.4 to 0.6 wt.% Mn, 0.12 wt.% max. Fe, 0.1 wt.% max. Si, the remainder aluminum and incidental elements and impurities, the skin having a minimum long transverse yield strength of 40 ksi, a minimum T-L fracture toughness of 140 ksi √in.

51. A damage tolerant aircraft wing skin comprised of an aluminum base alloy, the skin having high strength and improved levels of fracture toughness and resistance to fatigue crack growth in the solution heat treated, quenched and naturally aged condition, the skin comprised of an aluminum base alloy containing 4.0 to 4.5 wt.% Cu, 1.2 to 1.5 wt.% Mg, 0.4 to 0.6 wt.% Mn, 0.12 wt.% max. Fe, 0.1 wt.% max. Si, the remainder aluminum and incidental elements and impurities, the skin having a minimum long transverse yield strength of 42 ksi, the skin having a thickness of 0.05 to 0.25 inch, a minimum T-L fracture toughness of 140 ksi √in, the skin having a volume fraction of particles including Al_2CuMg and Al_2Cu less 1.25 vol.% larger than 0.15 square μm.

52. A method of producing an aluminum base alloy sheet product having high strength levels and good levels of fracture toughness and resistance to fatigue crack growth comprising:

(a) providing a body of an aluminum base alloy containing 3.8 to 4.5 wt.% Cu, 1.2 to 1.85 wt.% Mg, 0.3 to 0.78 wt.% Mn, 0.5 wt.% max. Fe, 0.5 wt.% max. Si, the remainder aluminum, incidental elements and impurities;

(b) hot rolling the body to a slab;

(c) heating said slab to above 910°F to dissolve soluble constituents;

(d) hot rolling the slab in a temperature range of 600 to 850°F to a sheet product;

(e) solution heat treating;

(f) cooling; and

(g) naturally aging to provide a sheet product having high strength and improved levels of fracture toughness and resistance to fatigue crack growth.

53. A method of producing an aluminum base alloy sheet product having high strength levels and good levels of fracture toughness and resistance to fatigue crack growth comprising:

(a) providing a body of an aluminum base alloy containing 3.8 to 4.5 wt.% Cu, 1.2 to 1.85 wt.% Mg, 0.3 to 0.78 wt.% Mn, 0.5 wt.% max. Fe, 0.5 wt.% max. Si, the remainder aluminum, incidental elements and impurities;

(b) hot rolling the body to a slab in a temperature range of 600 to 900°F;

(c) reheating said slab to above 910°F;

(d) hot rolling the slab in a temperature range of 600 to 900°F to a sheet product;

(e) solution heat treating for a time of less than 60 minutes in a temperature range of 910 to 1050°F;

(f) rapidly cooling; and

(g) aging to provide a sheet product having high strength and good levels of fracture toughness and resistance to fatigue crack growth.

54. A method of producing an aluminum base alloy sheet product having high strength levels and good levels of fracture toughness and resistance to fatigue crack growth comprising:

(a) providing a body of an aluminum base alloy containing 3.8 to 4.5 wt.% Cu, 1.2 to 1.85 wt.% Mg, 0.3 to 0.78 wt.% Mn, 0.5 wt.% max. Fe, 0.5 wt.% max. Si, the remainder aluminum, incidental elements and impurities;

(b) hot rolling the body to a slab in a temperature range of 600 to 900°F;

(c) heating said slab to above 910°F;

(d) hot rolling the slab in a temperature range of 600 to 900°F to a sheet product;

(e) cold rolling to a sheet gauge having a thickness in the range of 0.05 to 0.25 inch;

(f) solution heat treating for a time of less than 15 minutes in a temperature range of 910 to 1050°F;

(g) rapidly cooling; and

(h) naturally aging to provide a sheet product having high strength and good levels of fracture toughness and resistance to fatigue crack growth.

55. A method of producing an aluminum base alloy sheet product having high strength levels and improved levels of fracture toughness and resistance to fatigue crack growth comprising:

(a) providing a body of an aluminum base alloy containing 3.8 to 4.5 wt.% Cu, 1.2 to 1.85 wt.% Mg, 0.3 to 0.78 wt.% Mn, 0.5 wt.% max. Fe, 0.5 wt.% max. Si, the remainder aluminum, incidental elements and impurities;

(b) hot rolling the body to a slab in a temperature range of 600 to 900°F;

(c) reheating said slab to above 910°F to dissolve soluble constituents;

(d) hot rolling the slab in a temperature range of 600 to 850°F;

(e) cold rolling to a sheet gauge having a thickness in the range of 0.05 to 0.25 inch;

(f) solution heat treating for a time of less than 15 minutes in a temperature range of 910 to 1050°F;

(g) rapidly cooling; and

(h) naturally aging to provide a sheet product having high strength and improved levels of fracture toughness and resistance to fatigue crack growth.

56. In a method of producing an aluminum base alloy aircraft skin wherein an aluminum alloy product is formed to produce said aircraft skin, the improvement wherein said product is provided as an aluminum base alloy containing 3.8 to 4.5 wt.% Cu, 1.2 to 1.85 wt.% Mg, 0.3 to 0.78 wt.% Mn, 0.5 wt.% max. Fe, 0.5 wt.% max. Si, the remainder aluminum, incidental elements and impurities, the product further provided in the condition resulting from:

(a) hot rolling said alloy to a slab in a temperature range of 600 to 900°F;

(b) heating said slab to above 910°F to dissolve soluble constituents;

(c) hot rolling the slab in a temperature range of 600 to 900°F to a sheet product;

(d) solution heat treating the sheet product;

(e) cooling; and

(f) naturally aging to provide a sheet product having high strength and good levels of fracture toughness and resistance to fatigue crack growth.

57. In a method of producing an aluminum base alloy aircraft skin wherein an aluminum alloy sheet product is formed to produce said aircraft skin product, the improvement wherein said sheet product is provided as an aluminum base alloy containing 3.8 to 4.5 wt.% Cu, 1.2 to 1.85 wt.% Mg, 0.3 to 0.78 wt.% Mn, 0.5 wt.% max. Fe, 0.5 wt.% max. Si, the remainder aluminum, incidental elements and impurities, the sheet product further provided in the condition resulting from:

(a) hot rolling the alloy to a slab in a temperature range of 600 to 900°F;

(b) heating said slab to above 910°F to dissolve soluble constituents;

(c) hot rolling the slab in a temperature in the range of 600 to 900°F to a sheet product;

(d) solution heat treating for a time of less than 15 minutes in a temperature range of 910 to 1050°F;

(e) rapidly cooling; and

(f) naturally aging to provide a sheet product having high strength and good levels of fracture toughness and resistance to fatigue crack growth.

58. In a method of producing a damage tolerant aluminum base alloy aircraft fuselage skin product, the improvement wherein said product is provided as an aluminum base alloy containing 3.8 to 4.5 wt.% Cu, 1.2 to 1.85 wt.% Mg, 0.3 to 0.78 wt.% Mn, 0.5 wt.% max. Fe, 0.5 wt.% max. Si, the remainder aluminum, incidental elements and impurities, the product further provided in the condition resulting from:

(a) hot rolling said alloy in a temperature range of 600 to 900°F to form a slab;

(b) heating said slab to above 910°F;

(c) hot rolling the slab in a temperature range of 600 to 900°F;

(d) cold rolling to a sheet gauge having a thickness in the range of 0.05 to 0.25 inch;

(e) solution heat treating for a time of less than 15 minutes in a temperature range of 910 to 1050°F;

(f) rapidly cooling; and

(g) naturally aging to provide a sheet product having high strength and good levels of fracture toughness and resistance to fatigue crack growth.

AS ORIGINALLY FILED

07572626

Strength versus Toughness Plot for New Product and 2024-T3

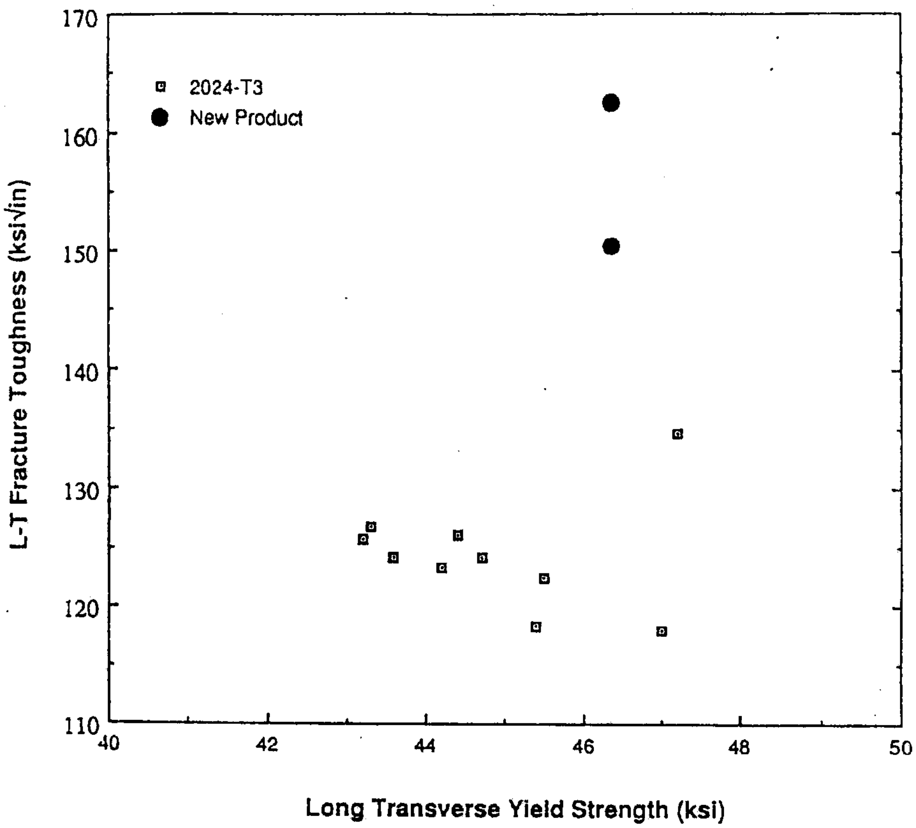


FIGURE 1

AS ORIGINALLY FILED

07/572626

FATIGUE CRACK GROWTH RATE VS. CRACK LENGTH
FOR 2024-T3 AND THE IMPROVED PRODUCT
ΔK=22 ksi√in., R=0.33, T-L ORIENTATION

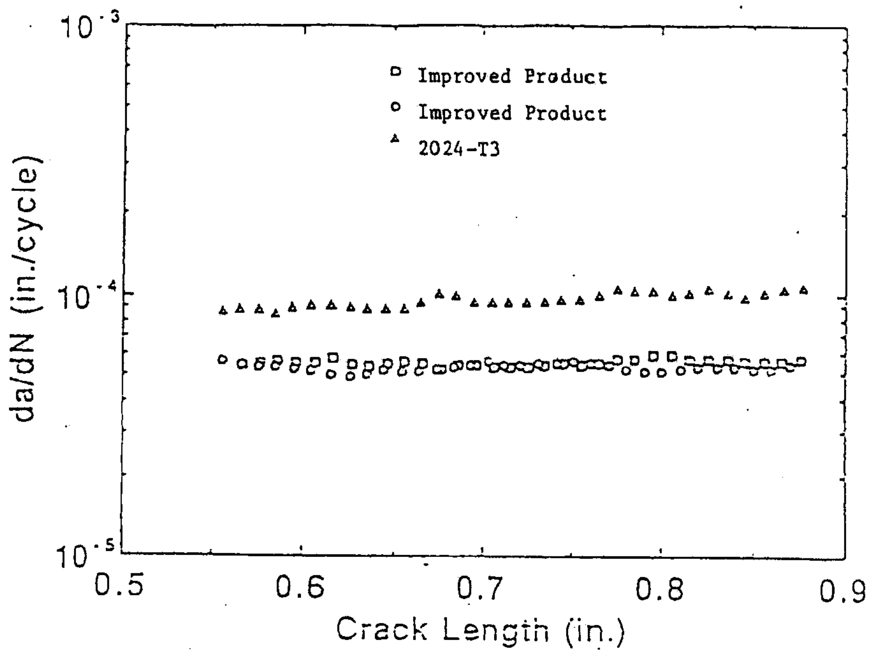
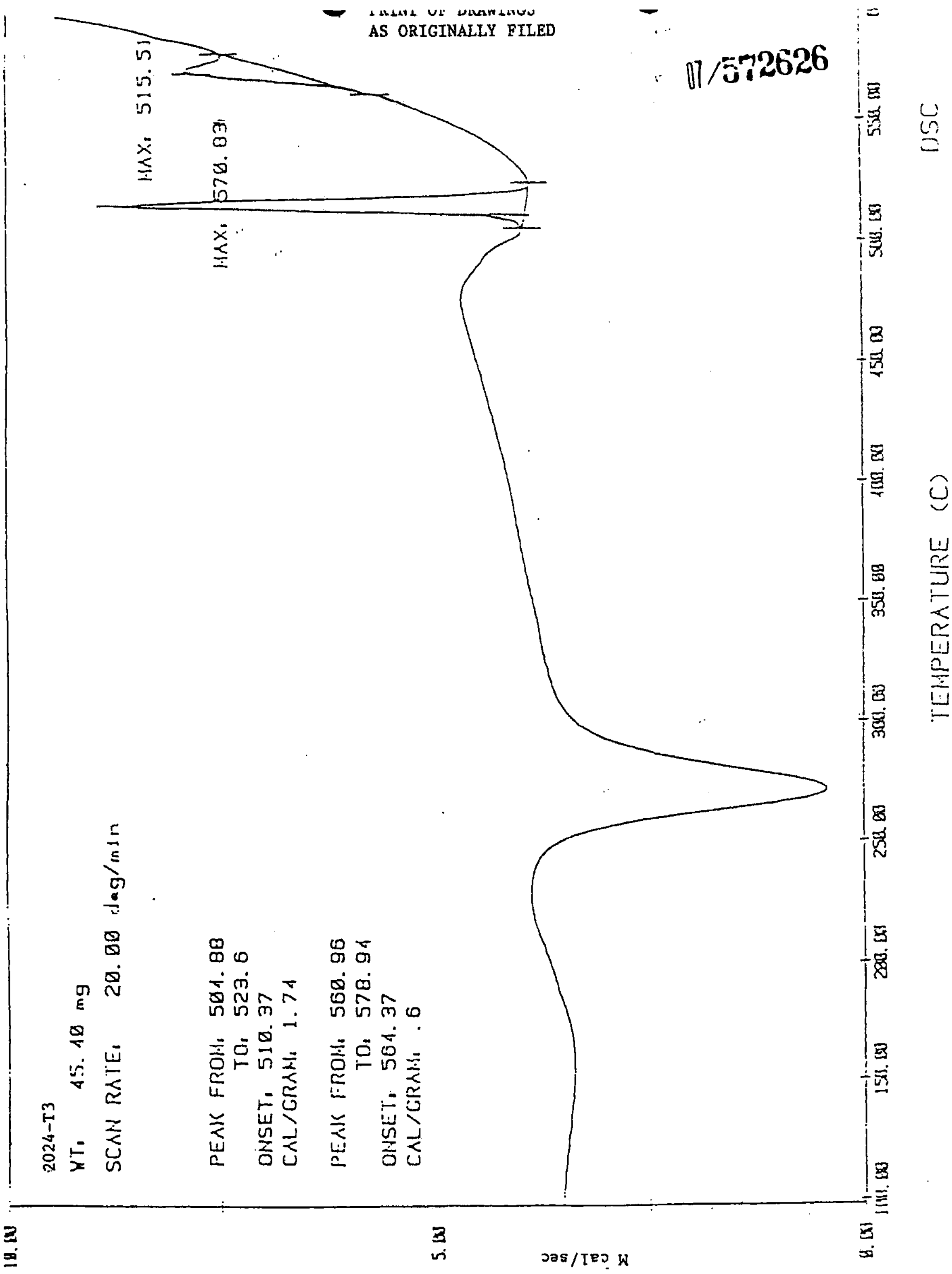


FIGURE 2


AS ORIGINALLY FILED
07/572626
MAX: 515.51
MAX: 570.83
2024-T3
WT. 45.40 mg
SCAN RATE: 20.00 deg/min
PEAK FROM: 504.88
TO: 523.6
ONSET: 510.37
CAL/GRAM: 1.74
PEAK FROM: 560.96
TO: 578.94
ONSET: 564.37
CAL/GRAM: .6
100.00
150.00
200.00
250.00
300.00
350.00
400.00
450.00
500.00
550.00
TEMPERATURE (C)
DSC
10.00
5.00
0.00
M cal/sec

PRINT OF DRAWINGS
AS ORIGINALLY FILED

07/572626

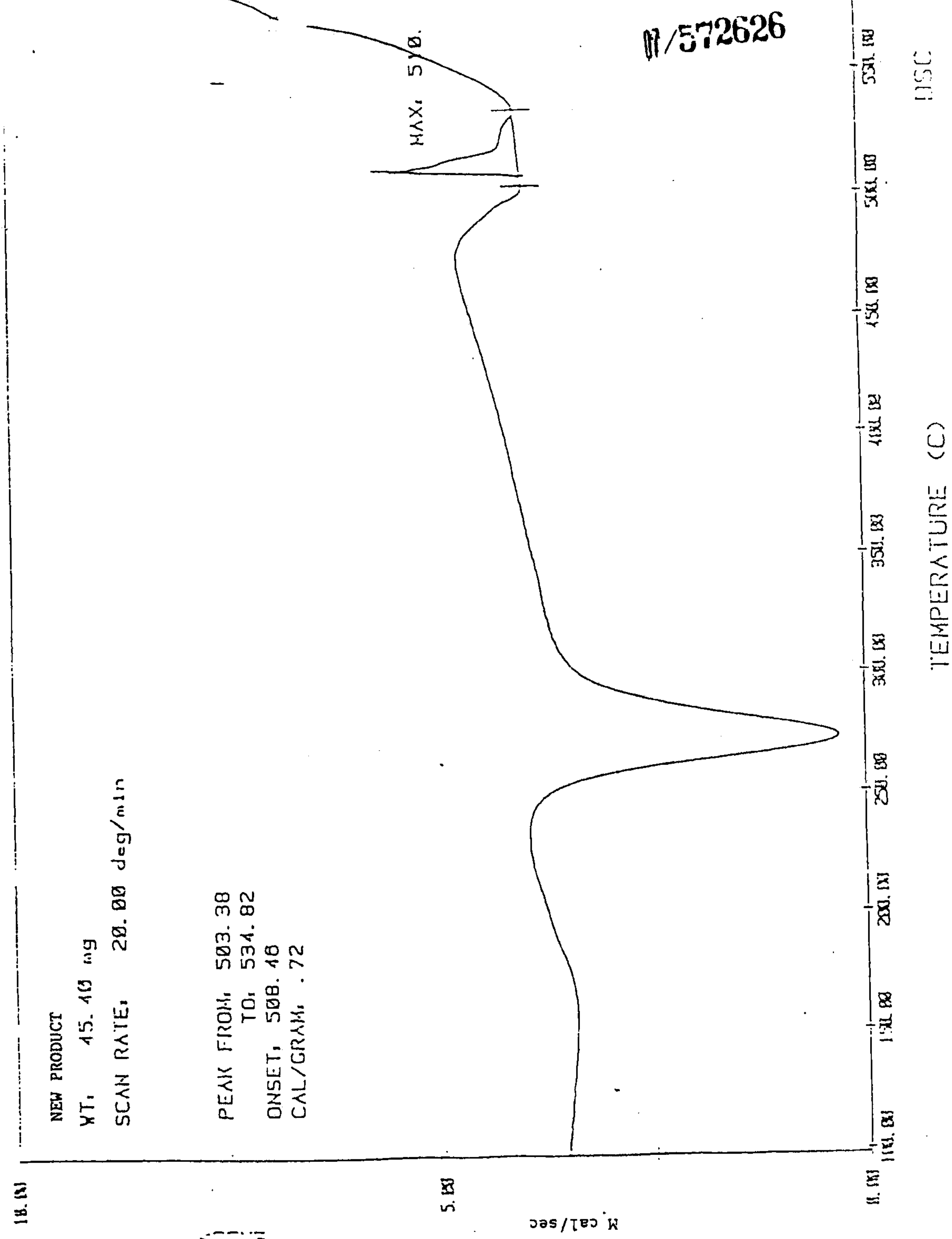


Exhibit 6

SERIAL NUMBER (Series of 1987) 07/572626 | PATENT DATE | PATENT NUMBER | ABANDONED

SERIAL NUMBER	FILING DATE	CLASS	SUBCLASS	GROUP ART UNIT	EXAMINER
07/572,626	08/27/90	~~428~~ 148	693 ~~72.7A~~	111	SCHUMA[illegible]

APPLICANTS: JOCELYN I. PETIT, NEW KENSINGTON, PA; ROBERT W. WESTERLUND, BETTENDORF, IA; EDWARD L. COLVIN, O'HARA TWP., PA.

KOEHL[illegible]

CONTINUING DATA*******************
VERIFIED
RRK

FOREIGN/PCT APPLICATIONS**********
VERIFIED
RRK

NOTE - DISCLAIMER
The term of this patent subsequent to ________ has been disclaimed

Foreign priority claimed / 35 USC 119 conditions met / Verified and Acknowledged	AS FILED	STATE OR COUNTRY	SHEETS DRWGS	TOTAL CLAIMS	INDEP CLAIMS	FILING FEE RECEIVED	ATTORNEY'S DOCKET NO.
☐ yes ☒ no / ☐ yes ☒ no / RRK Examiner's initials		PA	4	58	24	$1,582.00	

ADDRESS: ANDREW ALEXANDER
ALUMINUM COMPANY OF AMERICA
ALCOA CENTER, PA 15069

TITLE: DAMAGE TOLERANT ALUMINUM ALLOY SHEET FOR AIRCRAFT SKIN

U.S. DEPT. of COMM.- Pat, & TM Office—PTO-436L (rev. 10

PARTS OF APPLICATION FILED SEPARATELY

NOTICE OF ALLOWANCE MAILED: July 1, 1992

PREPARED FOR ISSUE 8/13/92
Robert R. Koehler — Assistant Examiner
Docket Clerk

R. DEAN
PRIMARY EXAMINER
GROUP 110 - ART UNIT 111
RDD 1/1/01
Primary Examiner

CLAIMS ALLOWED
Total Claims	Print Claim
57	1

DRAWING
Sheets Drwg.	Figs. Drwg.	Print Fig.
4	4	1

ISSUE FEE
Amount Due	Date Paid
$1130.00	

ISSUE CLASSIFICATION
Class	Subclass
148	693

ISSUE BATCH NUMBER E26

FORM PTO-1267 U.S. DEPT. OF COMMERCE PAT. & TM OFF. (REV. 8-78)
DISCLAIMER LABEL
SERIAL NO.	FILING DATE
572,626	08/27/90

A terminal disclaimer has been entered and recorded under 35 U.S.C. 253 in this file by Patent Issue Division.
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Form PTO-436
Rev. 5/89

UNITED STATES DEPARTMENT OF COMMERCE
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Washington, D.C. 20231

SERIAL NUMBER	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.
07/572,626	08/27/90	PETIT	

J

EXAMINER	
KOEHLER,R	
ART UNIT	PAPER NUMBER
111	8.

ANDREW ALEXANDER
ALUMINUM COMPANY OF AMERICA
ALCOA CENTER, PA 15069

DATE MAILED: 08/22/91

This is a communication from the examiner in charge of your application.
COMMISSIONER OF PATENTS AND TRADEMARKS

☒ This application has been examined ☐ Responsive to communication filed on ____________ ☐ This action is made final.

A shortened statutory period for response to this action is set to expire 3 month(s), ~~____ days~~ from the date of this letter.
Failure to respond within the period for response will cause the application to become abandoned. 35 U.S.C. 133

Part I THE FOLLOWING ATTACHMENT(S) ARE PART OF THIS ACTION:

1. ☒ Notice of References Cited by Examiner, PTO-892.
2. ☒ Notice re Patent Drawing, PTO-948.
3. ☒ Notice of Art Cited by Applicant, PTO-1449.
4. ☐ Notice of Informal Patent Application, Form PTO-152
5. ☐ Information on How to Effect Drawing Changes, PTO-1474.
6. ☐ ____________

Part II SUMMARY OF ACTION

1. ☒ Claims 1 to 58 are pending in the application.

   Of the above, claims ____________ are withdrawn from consideration.

2. ☐ Claims ____________ have been cancelled.
3. ☐ Claims ____________ are allowed.
4. ☒ Claims 1 to 58 are rejected.
5. ☐ Claims ____________ are objected to.
6. ☐ Claims ____________ are subject to restriction or election requirement.
7. ☒ This application has been filed with informal drawings under 37 C.F.R. 1.85 which are acceptable for examination purposes.
8. ☐ Formal drawings are required in response to this Office action.
9. ☐ The corrected or substitute drawings have been received on ____________. Under 37 C.F.R. 1.84 these drawings are ☐ acceptable; ☐ not acceptable (see explanation or Notice re Patent Drawing, PTO-948).
10. ☐ The proposed additional or substitute sheet(s) of drawings, filed on ____________, has (have) been ☐ approved by the examiner; ☐ disapproved by the examiner (see explanation).
11. ☐ The proposed drawing correction, filed ____________, has been ☐ approved; ☐ disapproved (see explanation).
12. ☐ Acknowledgement is made of the claim for priority under U.S.C. 119. The certified copy has ☐ been received ☐ not been received ☐ been filed in parent application, serial no. ____________; filed on ____________.
13. ☐ Since this application apppears to be in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under Ex parte Quayle, 1935 C.D. 11; 453 O.G. 213.
14. ☐ Other

TOL-326 (Rev.9-89)

The following is a quotation of the appropriate paragraphs of 35 U.S.C. § 102 that form the basis for the rejections under this section made in this Office action:

> A person shall be entitled to a patent unless --
> (b) the invention was patented or described in a printed publication in this or a foreign country or in public use or on sale in this country, more than one year prior to the date of application for patent in the United States.
>
> (e) the invention was described in a patent granted on an application for patent by another filed in the United States before the invention thereof by the applicant for patent, or on an international application by another who has fulfilled the requirements of paragraphs (1), (2), and (4) of section 371(c) of this title before the invention thereof by the applicant for patent.

Claims 1 to 35 and 52 to 58 are rejected under 35 U.S.C. § 102(b) and (e) as being anticipated by Cho (U.S. Patent No. 4,816,087).

Cho discloses process steps for alloy AA2024 involving hot working, reheating the alloy, a second hot working, solution heat treating, rapid cooling, and natural aging with process times and temperatures that overlap applicants' claimed procedure for these Al-Cu-Mg alloys. See lines 42 to 68 in column 5, lines 8 to 9 in column 6, and lines 14 to 17 in column 7.

The following is a quotation of 35 U.S.C. § 103 which forms the basis for all obviousness rejections set forth in this Office action:

> A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that

> the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.
>
> Subject matter developed by another person, which qualifies as prior art only under subsection (f) or (g) of section 102 of this title, shall not preclude patentability under this section where the subject matter and the claimed invention were, at the time the invention was made, owned by the same person or subject to an obligation of assignment to the same person.

This application currently names joint inventors. In considering patentability of the claims under 35 U.S.C. § 103, the examiner presumes that the subject matter of the various claims was commonly owned at the time any inventions covered therein were made absent any evidence to the contrary. Applicant is advised of the obligation under 37 C.F.R. § 1.56 to point out the inventor and invention dates of each claim that was not commonly owned at the time a later invention was made in order for the examiner to consider the applicability of potential 35 U.S.C. § 102(f) or (g) prior art under 35 U.S.C. § 103.

Claims 1 to 64 are rejected under 35 U.S.C. § 103 as being unpatentable over Cho (U.S. Patent No. 4,816,087) in view of Hyatt, et al. (U.S. Patent No. 4,294,625).

Cho discloses a process of heat treating Al-Cu-Mg alloys (similar to alloy AA2024) involving hot working, reheating the alloy, a second hot working, solution heat treating, rapid cooling, and natural aging with process times and temperatures that overlap applicants' claimed procedure for these Al-Cu-Mg alloys. These heat treated alloys possess fracture toughness and tensile yield stress properties which overlap applicants' claimed

Al alloys. See lines 42 to 68 in column 5, lines 8 to 9 in column 6, lines 14 to 17 in column 7, and figure 3. Cho does not describe any preferred volume concentration of intermetallic compounds (e.g., Al, Cu_2Fe and $CuMgAl_2$), but Hyatt, et al. teach that these compounds must be present in amounts less than 1.5 volume percent in order that fracture toughness of the alloy does not fall below the desired levels. See lines 50 to 65 in column 4. Hyatt, et al. defined the volume percent of these compounds for Al-Cu-Mg alloys having composition ranges which overlap the applicants' claimed alloy compositions. See claim 11 in column 13. It would have been obvious at the time of the applicants' claimed process for making an Al-Cu-Mg alloy for a person skilled in the art of aluminum alloy metallurgy to combine the disclosure of Cho in view of Hyatt, et al. and arrive at the applicants' claimed process and Al alloy. It would have been obvious for a skilled person to combine these two reference because both patents are concerned with the improvement of fracture toughness <u>and</u> tensile yield strength in Al-Cu-Mg alloys by thermomechanical treatment involving hot working, solution heat treating, and homogenizing.

Claim s 21 and 25 are rejected under 35 U.S.C. § 112, fourth paragraph, as being of improper dependent form for failing to further limit the subject matter of a previous claim.

Claims 21 and 25 are rejected because they do not provide any additional limitation to the hot roll temperature ranges of steps (a) and (c) in claim 20.

The following is a quotation of the first paragraph of 35 U.S.C. § 112:

> The specification shall contain a written description of the invention, and of the manner and process of making and using it, in such full, clear, concise, and exact terms as to enable any person skilled in the art to which it pertains, or with which it is most nearly connected, to make and use the same and shall set forth the best mode contemplated by the inventor of carrying out his invention.

The specification is objected to under 35 U.S.C. § 112, first paragraph, as failing to provide an adequate written description of the invention.

On page 10 of the specification, lines 15 to 17, applicants state that the Al stock sheet has a fatigue crack growth rate of 10^{-4} inches per cycle, but the plot of da/dN *versus* crack length in figure 2 for the improved product shows growth rates much less than 10^{-4} (approx. $6x10^{-5}$).

Claim 39 is rejected under 35 U.S.C. § 112, first paragraph, for the reasons set forth in the objection to the specification.

The specification (see page 12, lines 5 to 7) states a growth rate of $5.3x10^{-5}$ for the improved product.

Claims 52 to 58 are rejected under 35 U.S.C. § 112, first

paragraph, as the disclosure is enabling only for claims limited to Al alloys with 4.0 to 4.5% Cu, 1.2 to 1.5% Mg, and 0.4 to 0.7% Mn. See page 4 of the specification, lines 3 to 6. The specification does not teach or suggest that <u>lower</u> levels of Cu, Mg, and Mn should be present in these Al alloys. See M.P.E.P. §§ 706.03(n) and 706.03(z).

Claims 1 to 58 are provisionally rejected under the judicially created doctrine of obviousness-type double patenting as being unpatentable over claims 1 to 64 of copending application Serial No. 07/572,625. Although the conflicting claims are not identical, they are not patentably distinct from each other because both applications disclose similar Al-Cu-Mg alloys, similar thermomechanical treatments of the alloys, and similar usage of alloys in aircraft structures (including clad aluminum alloy structures).

This is a *provisional* obviousness-type double patenting rejection because the conflicting claims have not in fact been patented.

Claims 1 to 58 are provisionally rejected under the judicially created doctrine of obviousness-type double patenting as being unpatentable over claims 1 to 41 of copending application Serial No. 07/620,626. Although the conflicting claims are not

identical, they are not patentably distinct from each other because both applications disclose similar Al-Cu-Mg alloys, similar thermomechanical treatments of the alloys, and similar usage of alloys in aircraft structures (including clad aluminum alloy structures).

This is a *provisional* obviousness-type double patenting rejection because the conflicting claims have not in fact been patented.

The obviousness-type double patenting rejection is a judicially established doctrine based upon public policy and is primarily intended to prevent prolongation of the patent term by prohibiting claims in a second patent not patentably distinct from claims in a first patent. *In re Vogel*, 164 USPQ 619 (CCPA 1970). A timely filed terminal disclaimer in compliance with 37 C.F.R. § 1.321(b) would overcome an actual or provisional rejection on this ground provided the conflicting application or patent is shown to be commonly owned with this application. See 37 C.F.R. § 1.78(d).

Any inquiry concerning this communication or earlier communications from the examiner should be directed to Robert Koehler whose telephone number is (703) 308-3188.

Any inquiry of a general nature or relating to the status of this application should be directed to the Group receptionist whose telephone number is (703) 308-0661.

R. Dean

R. DEAN
PRIMARY EXAMINER
GROUP 110 - ART UNIT 111

R. Koehler:rg RRK
August 20, 1991

Exhibit 7

ABANDONED

SERIAL NUMBER (Series of 1987) 07/572626

PATENT DATE

PATENT NUMBER

SERIAL NUMBER	FILING DATE	CLASS	SUBCLASS	GROUP ART UNIT	EXAMINER
07/572,626	08/27/90	~~428~~ 148	693 ~~72.7A~~	111	~~SCHUMA~~ KOEHLE

APPLICANTS

JOCELYN I. PETTIT, NEW KENSINGTON, PA; ROBERT W. WESTERLUND, BETTENDORF, IA; EDWARD L. COLVIN, O'HARA TWP., PA.

CONTINUING DATA*********************
VERIFIED
RRK

FOREIGN/PCT APPLICATIONS**********
VERIFIED
RRK

NOTE - DISCLAIMER
The term of this patent subsequent to ______ has been disclaimed

Foreign priority claimed / 35 USC 119 conditions met / Verified and Acknowledged		AS FILED	STATE OR COUNTRY	SHEETS DRWGS	TOTAL CLAIMS	INDEP CLAIMS	FILING FEE RECEIVED	ATTORNEY'S DOCKET NO.
☐ yes ☒ no / ☐ yes ☒ no / RRK Examiner's initials		→	PA	4	58	24	$1,582.00	

ADDRESS

ANDREW ALEXANDER
ALUMINUM COMPANY OF AMERICA
ALCOA CENTER, PA 15069

TITLE

DAMAGE TOLERANT ALUMINUM ALLOY SHEET FOR AIRCRAFT SKIN

U.S. DEPT. of COMM.- Pat. & TM Office—PTO-436L (rev. 10-

PARTS OF APPLICATION FILED SEPARATELY

NOTICE OF ALLOWANCE MAILED
Oct 1, 1992

ISSUE FEE

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Assistant Examiner

Docket Clerk

ROO
R. DEAN
PRIMARY EXAMINER
GROUP 110 - ART UNIT 111
Primary Examiner 1/01

CLAIMS ALLOWED

Total Claims	Print Claim
57	1

DRAWING

Sheets Drwg.	Figs. Drwg.	Print Fig.
4	4	1

FORM PTO-1267 U.S. DEPT. OF COMMERCE PAT. & TM OFF.
(REV. 8-75)

DISCLAIMER LABEL

SERIAL NO.	FILING DATE
572,626	08/27/90

A terminal disclaimer has been entered and recorded under 35 U.S.C. 253 in this file by Patent Issue Division.

DO NOT DESTROY

ISSUE CLASSIFICATION

Class	Subclass
148	693

ISSUE BATCH NUMBER E26

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RECEIVED

GROUP 110

In re application of	)	
Jocelyn I. Petit et al	)	
Serial No. 07/572,626	)	Group Art Unit 111
Filed August 27, 1990	)	Examiner R. Koehler
For Damage Tolerant Aluminum Alloy Sheet for Aircraft Skin	)	

I hereby certify that this correspondence is being deposited with the United States Postal Service as first class mail in an envelope addressed to: Commissioner of Patent and Trademarks, Washington, D.C. 20231 on February 21, 1992.

Carl R. Lippert

Carl R. Lippert, Reg. No. 22313
Date of Signature: February 21, 1992

BOX NON-FEE AMENDMENT
Commissioner of Patents and Trademarks
Washington, D.C. 20231

Sir:

In response to the Office Action dated August 22, 1991, please amend the above-identified application as follows:

Cancel claim 29.

Please rewrite claims 1, 3, 11-13, 16-20, 22, 28, 34-36, 39, and 45-58 as follows:

1. (Amended) A method of producing an aluminum base alloy sheet product having [high] good strength levels and good levels of fracture toughness and resistance to fatigue crack growth comprising:

(a) providing a body [of] comprising an aluminum base alloy [containing 4.0] consisting essentially of about 4 to 4.5 wt.% Cu, 1.2 to 1.5 wt.% Mg, 0.4 to 0.7 wt.% Mn, 0.5 wt.% max. Fe, 0.5 wt.% max. Si, the remainder substantially aluminum, incidental elements and impurities;

(b) hot rolling the body to a slab;

(c) heating said slab [to above 910°F to dissolve soluble constituents] within 900° to 945°F;

(d) hot rolling the slab [in a temperature range of 600 to 850°F to a sheet product];

(e) solution heat treating; and

(f) cooling[; and

(g) naturally aging to provide a sheet product having high strength and improved levels of fracture toughness and resistance to fatigue crack growth].

3. (Amended) The method in accordance with claim 1 wherein the [sheet product] metal is cold rolled [to a final sheet gauge] after [said] hot rolling.

11. (Amended) A method of producing an aluminum base alloy sheet product having [high] good strength levels and good levels of fracture toughness and resistance to fatigue crack growth comprising:

(a) providing a body [of] comprising an aluminum base alloy [containing] consisting essentially of about 4.1 to 4.4 wt.% Cu, 1.2 to 1.45 wt.% Mg, 0.4 to 0.6 wt.% Mn, 0.12 wt.% max. Fe, 0.1 wt.% max. Si, the remainder substantially aluminum, incidental elements and impurities;

(b) hot rolling the body to a slab in a temperature range of 600 to 900°F;

(c) [reheating] heating said slab [to above 910°F] within 900° to 945°F for more than one hour;

(d) hot rolling the slab in a temperature range of 600 to 900°F to a sheet product;

(e) solution heat treating for a time of less than 60 minutes [in a temperature range of 910 to 1050°F] within 910° to 945°F;

(f) rapidly cooling; and

(g) aging [to provide a sheet product having high strength and good levels of fracture toughness and resistance to fatigue crack growth].

12. (Amended) The method in accordance with claim [11] 1 wherein [the sheet is solution heat treated in a temperature range of 910 to 945°F] subsequent to said cooling there is imparted a cold working effect substantially equivalent to stretching up to 10% at room temperature.

A3 cont'd

13. (Amended) The method in accordance with claim [11] 1 wherein [the sheet is solution heat treated for less than 15 minutes] subsequent to said cooling there is imparted a cold working effect substantially equivalent to stretching about 0.5 to 6% at room temperature.

A4

16. (Amended) The method in accordance with claim 11 wherein [after] subsequent to hot rolling the [sheet] metal is cold rolled to a cold rolled gauge in the range of 0.05 to 0.25 inch.

17. (Amended) A method of producing an aluminum base alloy sheet product having [high] good strength levels and good levels of fracture toughness and resistance to fatigue crack growth comprising:

(a) providing a body [of] comprising an aluminum base alloy [containing 4.0] consisting essentially of about 4 to 4.5 wt.% Cu, 1.2 to 1.4 wt.% Mg, 0.4 to 0.6 wt.% Mn, 0.5 wt.% max. Fe, 0.5 wt.% max. Si, the remainder substantially aluminum, incidental elements and impurities;

OK to ent.

(b) hot rolling the body to a slab [in a temperature range of 600 to 900°F];

(c) heating said slab [to above 910°F] within 900° to 945°F;

(d) hot rolling the slab [in a temperature range of 600 to 900°F to a sheet product];

(e) cold rolling to a sheet gauge having a thickness in the range of 0.05 to 0.25 inch;

(f) solution heat treating [for a time of less than 15 minutes in a temperature range of 910 to 1050°F] within 910° to 945°F;

(g) rapidly cooling; and

(h) naturally aging [to provide a sheet product having high strength and good levels of fracture toughness and resistance to fatigue crack growth].

18. (Amended) A method of producing an aluminum base alloy sheet product having [high] good strength and improved levels of fracture toughness and fatigue crack growth resistance comprising:

(a) providing a body [of] comprising an aluminum base alloy [containing] consisting essentially of about 4.1 to 4.4 wt.% Cu, 1.2 to 1.45 wt.% Mg, 0.4 to 0.6 wt.% Mn, 0.12 wt.% max. Fe, 0.1 wt.% max. Si, the remainder substantially aluminum, incidental elements and impurities;

(b) hot rolling the body to a slab [in a temperature in the range of 600 to 900°F];

(c) [reheating] heating said slab [to] within 910 to 945°F [to dissolve soluble constituents] for at least one hour;

(d) hot rolling the slab [in a temperature range of 600 to 850°F];

(e) cold rolling to a sheet gauge product having a thickness in the range of 0.05 to 0.25 inch;

(f) solution heat treating said product [for a time of less than 15 minutes at a solution heat treating temperature in the range of 910 to 1050°F] within 910° to 945°F;

(g) rapidly cooling; and

(h) naturally aging [said product to provide a sheet product having high strength and improved levels of fracture toughness and resistance to fatigue crack growth].

19. (Amended) A method of producing an aluminum base alloy sheet product having [high] good strength levels and improved levels of fracture toughness and resistance to fatigue crack growth comprising:

(a) providing a body [of] comprising an aluminum base alloy containing 4.1 to 4.5 wt.% Cu, 1.2 to 1.5 wt.% Mg, 0.4 to 0.6 wt.% Mn, 0.12 wt.% max. Fe, 0.1 wt.% max. Si, the remainder substantially aluminum, incidental elements and impurities;

Q4 contd.

(b) hot rolling the body to a slab [in a temperature range of 600 to 900°F];

(c) [reheating] heating said slab [to above 910°F to dissolve soluble constituents] within 900° to 945°F;

(d) further hot rolling the slab [in a temperature range of 600 to 850°F];

(e) cold rolling to a sheet gauge having a thickness in the range of 0.05 to 0.25 inch;

(f) solution heat treating for a time of less than 15 minutes [in a temperature range of 910 to 1050°F] within 910° to 945°F;

(g) rapidly cooling; and

(h) naturally aging [to provide a sheet product having high strength and improved levels of fracture toughness and resistance to fatigue crack growth].

20. (Amended) In a method of producing [an aluminum base alloy] aircraft skin wherein an aluminum alloy product is [formed to produce] used in producing said aircraft skin, the improvement wherein said product is provided [as] by the method comprising:

A4 cont.

(a) providing a body comprising an aluminum base alloy [containing 4.0] consisting essentially of about 4 to 4.5 wt.% Cu, 1.2 to 1.45 wt.% Mg, 0.4 to 0.6 wt.% Mn, 0.12 wt.% max. Fe, 0.1 wt.% max. Si, the remainder substantially aluminum, incidental elements and impurities; [, the product further provided in the condition resulting from:]

[(a)] (b) hot rolling said alloy to a slab [in a temperature range of 600 to 900°F];

[(b)] (c) heating said slab [to above 910°F to dissolve soluble constituents] within about 900° to 945°F;

[(c)] (d) hot rolling the slab [in a temperature range of 600 to 900°F to a sheet product];

[(d)] (e) solution heat treating [the sheet product]; and

[(e)] (f) cooling[; and

(f) naturally aging to provide a sheet product having high strength and good levels of fracture toughness and resistance to fatigue crack growth].

22. (Amended) The method in accordance with claim 20 wherein the sheet product is cold rolled to a final sheet gauge after [said] hot rolling [step].

a5

28. (Amended) In a method of producing [an aluminum base alloy] aircraft skin wherein an aluminum alloy sheet product is formed [to produce] in producing said aircraft skin product, the improvement wherein said sheet product is provided [as] by the method comprising:

(a) providing a body comprising an aluminum base alloy [containing] consisting essentially of about 4.1 to 4.4 wt.% Cu, 1.2 to 1.45 wt.% Mg, 0.4 to 0.6 wt.% Mn, 0.12 wt.% max. Fe, 0.1 wt.% max. Si, the remainder substantially aluminum, incidental elements and impurities; [, the sheet product further provided in the condition resulting from:]

[(a)] (b) hot rolling the alloy to a slab [in a temperature range of 600 to 900°F];

[(b)] (c) heating said slab [to above 910°F to dissolve soluble constituents] within about 900° to 945°F for more than one hour;

[(c)] (d) hot rolling the slab [in a temperature in the range of 600 to 900°F to a sheet product];

[(d)] (e) solution heat treating [for a time of less than 15 minutes in a temperature range of 910 to 1050°F] within 910° to 945°F; and

[(e)] (f) rapidly cooling[; and

(f) naturally aging to provide a sheet product having high strength and good levels of fracture toughness and resistance to fatigue crack growth].

33 ~~34.~~ ~~(Amended)~~ In a method of producing [a damage tolerant] an aluminum [base alloy] aircraft fuselage skin product from an aluminum sheet product, the improvement wherein said aluminum sheet product is provided [as] by the method comprising:

(a) providing a body comprising an aluminum base alloy [containing 4.0] consisting essentially of about 4 to 4.5 wt.% Cu, 1.2 to 1.45 wt.% Mg, 0.4 to 0.6 wt.% Mn, 0.12 wt.% max. Fe, 0.1 wt.% max. Si, the remainder substantially aluminum, incidental elements and impurities;[, the product further provided in the condition resulting from:]

[(a)] (b) hot rolling said alloy [in a temperature range of 600 to 900°F to form a slab];

[(b)] (c) heating said slab [to above 910°F] within 900° to 945°F for 4 hours or more;

[(c)] (d) hot rolling the slab [in a temperature range of 600 to 900°F];

[(d)] (e) cold rolling to a sheet gauge having a thickness in the range of 0.05 to 0.25 inch;

[(e)] (f) solution heat treating [for a time of less than 15 minutes in a temperature range of 910 to 1050°F]; and

[(f)] (g) rapidly cooling[; and

(g) naturally aging to provide a sheet product having high strength and good levels of fracture toughness and resistance to fatigue crack growth].

34 ~~35.~~ ~~(Amended)~~ In a method of producing [a damage tolerant aluminum base alloy] an aircraft wing skin product from an aluminum sheet or plate product, the improvement wherein said sheet or plate product is provided [as] by the method comprising:

(a) providing a body comprising an aluminum base alloy [containing 4.0] consisting essentially of about 4 to 4.5 wt.% Cu, 1.2 to 1.5 wt.% Mg, 0.4 to 0.6 wt.% Mn, 0.12 wt.% max. Fe, 0.1 wt.% max. Si, the remainder substantially aluminum, incidental elements and impurities;[, the product further provided in the condition resulting from:]

[(a)] (b) hot rolling the alloy to a slab [in a temperature range of 600 to 900°F];

[(b)] (c) heating said slab [to above 910°F] within 900° to 945°F for more than one hour;

[(c)] (d) further hot rolling the slab [in a temperature range of 600 to 850°F to a sheet product];

[(d) cold rolling to a sheet gauge having a thickness in the range of 0.05 to 0.25 inch;]

(e) solution heat treating [for a time of less than 15 minutes in a temperature range of 910 to 1050°F]; and

(f) rapidly cooling[; and

(g) naturally aging to provide a sheet product having high strength and good levels of fracture toughness and resistance to fatigue crack growth].

A 3 cont.

35 ~~36.~~ (~~Amended~~) [A damage tolerant] An aluminum base alloy sheet product having [high] good strength and improved levels of fracture toughness and resistance to fatigue crack growth, the sheet comprised of an aluminum base alloy [containing 4.0] consisting essentially of about 4 to 4.5 wt.% Cu, 1.2 to 1.45 wt.% Mg, 0.4 to 0.6 wt.% Mn, 0.12 wt.% max. Fe, 0.1 wt.% max. Si, the remainder substantially aluminum and incidental elements and impurities, the sheet having a minimum long transverse yield strength of 40 ksi[,] and a minimum T-L fracture K_{app} of [140] 88 ksi √in.

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38 ~~39.~~ (~~Amended~~) The sheet product in accordance with claim 35 ~~36~~ wherein the product has a T-L fatigue crack growth rate [of] less than 10^{-4} inches per cycle at a [minimum] cyclic stress intensity range of 22 ksi √in.

44
~~43.~~ ~~(Amended)~~ [A damage tolerant] An aluminum base alloy sheet product having [high] good strength and improved levels of fracture toughness and resistance to fatigue crack growth in the solution heat treated, quenched and aged condition, the sheet comprised of an aluminum base alloy [containing 4.0] consisting essentially of about 4 to 4.5 wt.% Cu, 1.2 to 1.5 wt.% Mg, 0.4 to 0.6 wt.% Mn, 0.12 wt.% max. Fe, 0.1 wt.% max. Si, the remainder substantially aluminum and incidental elements and impurities, the sheet having a minimum long transverse yield strength of [42] 40 ksi, the sheet having a thickness of 0.05 to 0.25 inch, a minimum T-L fracture toughness K_{app} of [140] 88 ksi √in[, the sheet having a volume fraction of particles including Al_2CuMg and Al_2Cu less than 1.25 vol.% larger than 0.15 square µm].

45
~~46.~~ ~~(Amended)~~ [A damage tolerant] An aircraft skin comprised of an aluminum base alloy product, [the skin having high strength and improved levels of fracture toughness and resistance to fatigue crack growth, the skin] said aluminum alloy product comprised of an aluminum base alloy [containing 4.0] consisting essentially of about 4 to 4.5 wt.% Cu, 1.2 to 1.45 wt.% Mg, 0.4 to 0.6 wt.% Mn, 0.1 wt.% max. Fe, 0.1 wt.% max. Si, the remainder substantially aluminum and incidental elements and impurities, [the skin] said aluminum alloy product having a minimum long transverse yield strength of 40 ksi, a minimum T-L fracture toughness K_{app} of [140] 88 ksi √in, and good resistance to fatigue crack growth.

46 ~~47.~~ ~~(Amended)~~ [A damage tolerant] An aircraft skin comprised of an aluminum [base] alloy product [, the skin] having [high] good strength and improved levels of fracture toughness and resistance to fatigue crack growth in the solution heat treated, quenched and naturally aged condition, the [skin] aluminum alloy product comprised of an aluminum base alloy [containing 4.0] consisting essentially of about 4 to 4.5 wt.% Cu, 1.2 to 1.5 wt.% Mg, 0.4 to 0.6 wt.% Mn, 0.1 wt.% max. Fe, 0.1 wt.% max. Si, the remainder substantially aluminum and incidental elements and impurities, [the skin] said aluminum alloy product having a minimum long transverse yield strength of 42 ksi, [the skin having] a thickness of 0.05 to 0.25 inch, and a minimum T-L fracture toughness K_{app} of [140] 88 ksi √in[, the skin having a volume fraction of particles including Al_2CuMg and Al_2Cu less 1.25 vol.% larger than 0.15 square μm].

19 cont'd

47 ~~48.~~ ~~(Amended)~~ [A damage tolerant] An aircraft fuselage skin comprised of an aluminum [base] alloy product [, the skin] having [high] good strength and improved levels of fracture toughness and resistance to fatigue crack growth, [the skin] said aluminum alloy product comprised of an aluminum base alloy [containing 4.0] consisting essentially of about 4 to 4.5 wt.% Cu, 1.2 to 1.5 wt.% Mg, 0.4 to 0.6 wt.% Mn, 0.12 wt.% max. Fe, 0.1 wt.% max. Si, the remainder substantially aluminum and incidental elements and impurities, [the skin] and having a minimum long transverse yield strength of 40 ksi[,] and a minimum T-L fracture toughness K_{app} of [140] 88 ksi √in.

48 ~~49.~~ (Amended) [A damage tolerant] An aircraft fuselage skin comprised of an aluminum [base] alloy product [, the skin] having [high] good strength and improved levels of fracture toughness and resistance to fatigue crack growth in the solution heat treated, quenched and naturally aged condition, the [skin] aluminum alloy product comprised of an aluminum base alloy [containing 4.0] consisting essentially of about 4 to 4.5 wt.% Cu, 1.2 to 1.5 wt.% Mg, 0.4 to 0.6 wt.% Mn, 0.12 wt.% max. Fe, 0.1 wt.% max. Si, the remainder substantially aluminum and incidental elements and impurities, [the skin] and having a minimum T-L yield strength of [42] 40 ksi, [the skin having] a thickness of 0.05 to 0.25 inch, and a minimum T-L fracture toughness K_{app} of [140] 88 ksi √in[, the skin having a volume fraction of particles including Al_2CuMg and Al_2Cu less 1.25 vol.% larger than 0.15 square μm].

49 ~~50.~~ ~~(Amended)~~ [A damage tolerant] An aircraft wing skin comprised of an aluminum [base] alloy product [, the skin] having [high] good strength and improved levels of fracture toughness and resistance to fatigue crack growth, the [skin] aluminum alloy product comprised of an aluminum base alloy [containing 4.0] consisting essentially of about 4 to 4.5 wt.% Cu, 1.2 to 1.5 wt.% Mg, 0.4 to 0.6 wt.% Mn, 0.12 wt.% max. Fe, 0.1 wt.% max. Si, the remainder substantially aluminum and incidental elements and impurities, [the skin] and having a minimum long transverse yield strength of 40 ksi, and a minimum T-L fracture toughness K_{app} of [140] 88 ksi √in.

50
~~51~~. ~~(Amended)~~ [A damage tolerant] An aircraft wing skin comprised of an aluminum [base] alloy product [, the skin] having [high] good strength and improved levels of fracture toughness and resistance to fatigue crack growth in the solution heat treated, quenched and naturally aged condition, the [skin] aluminum alloy product comprised of an aluminum base alloy [containing 4.0] consisting essentially of about 4 to 4.5 wt.% Cu, 1.2 to 1.5 wt.% Mg, 0.4 to 0.6 wt.% Mn, 0.12 wt.% max. Fe, 0.1 wt.% max. Si, the remainder substantially aluminum and incidental elements and impurities, [the skin having] a minimum long transverse yield strength of 42 ksi, [the skin having a thickness of 0.05 to 0.25 inch,] and a minimum T-L fracture toughness K_{app} of [140] 90 ksi √in[, the skin having a volume fraction of particles including Al_2CuMg and Al_2Cu less 1.25 vol.% larger than 0.15 square μm].

19 cont

51
~~52.~~ ~~(Amended~~) A method of producing an aluminum base alloy sheet product having [high] good strength levels and good levels of fracture toughness and resistance to fatigue crack growth comprising:

(a) providing a body [of] comprising an aluminum base alloy [containing] consisting essentially of about 3.8 to 4.5 wt.% Cu, 1.2 to 1.85 wt.% Mg, 0.3 to 0.78 wt.% Mn, 0.5 wt.% max. Fe, 0.5 wt.% max. Si, the remainder substantially aluminum, incidental elements and impurities;

A9 cont.

(b) hot rolling the body to a slab;

(c) heating said slab [to above 910°F to dissolve soluble constituents] within about 900° to 945°F;

(d) hot rolling the slab [in a temperature range of 600 to 850°F to a sheet product];

(e) solution heat treating; and

(f) cooling[; and

(g) naturally aging to provide a sheet product having high strength and improved levels of fracture toughness and resistance to fatigue crack growth].

52 ~~53.~~ ~~(Amended)~~ A method of producing an aluminum base alloy sheet product having [high] good strength levels and good levels of fracture toughness and resistance to fatigue crack growth comprising:

(a) providing a body [of] comprising an aluminum base alloy [containing] consisting essentially of about 3.8 to 4.5 wt.% Cu, 1.2 to 1.85 wt.% Mg, 0.3 to 0.78 wt.% Mn, 0.5 wt.% max. Fe, 0.5 wt.% max. Si, the remainder substantially aluminum, incidental elements and impurities;

(b) hot rolling the body to a slab [in a temperature range of 600 to 900°F];

(c) reheating said slab [to above 910°F] within about 900° to 945°F;

(d) hot rolling the slab [in a temperature range of 600 to 900°F to a sheet product];

(e) solution heat treating for a time of less than 60 minutes [in a temperature range of 910 to 1050°F] within 910° to 945°F;

(f) rapidly cooling; and

(g) aging [to provide a sheet product having high strength and good levels of fracture toughness and resistance to fatigue crack growth].

53
~~54.~~ ~~(Amended)~~ A method of producing an aluminum base alloy sheet product having [high] good strength levels and good levels of fracture toughness and resistance to fatigue crack growth comprising:

(a) providing a body [of] comprising an aluminum base alloy [containing] consisting essentially of about 3.8 to 4.5 wt.% Cu, 1.2 to 1.85 wt.% Mg, 0.3 to 0.78 wt.% Mn, 0.5 wt.% max. Fe, 0.5 wt.% max. Si, the remainder substantially aluminum, incidental elements and impurities;

A9 cont.

(b) hot rolling the body to a slab [in a temperature range of 600 to 900°F];

(c) heating said slab [to above 910°F] within about 900° to 945°F for more than one hour;

(d) hot rolling the slab [in a temperature range of 600 to 900°F to a sheet product];

(e) cold rolling to a sheet gauge having a thickness in the range of 0.05 to 0.25 inch;

(f) solution heat treating [for a time of less than 15 minutes in a temperature range of 910 to 1050°F]; and

(g) rapidly cooling[; and

(h) naturally aging to provide a sheet product having high strength and good levels of fracture toughness and resistance to fatigue crack growth].

54 ~~58~~. ~~(Amended)~~ A method of producing an aluminum base alloy sheet product having [high] good strength levels and improved levels of fracture toughness and resistance to fatigue crack growth comprising:

(a) providing a body [of] comprising an aluminum base alloy [containing] consisting essentially of about 3.8 to 4.5 wt.% Cu, 1.2 to 1.85 wt.% Mg, 0.3 to 0.78 wt.% Mn, 0.5 wt.% max. Fe, 0.5 wt.% max. Si, the remainder substantially aluminum, incidental elements and impurities;

(b) hot rolling the body to a slab [in a temperature range of 600 to 900°F];

(c) reheating said slab [to above 910°F to dissolve soluble constituents] within about 900° to 945°F for at least 4 hours;

(d) hot rolling the slab [in a temperature range of 600 to 850°F];

(e) cold rolling to a sheet gauge having a thickness in the range of 0.05 to 0.25 inch;

(f) solution heat treating [for a time of less than 15 minutes in a temperature range of 910 to 1050°F] within 910° to 945°F;

(g) rapidly cooling; and

(h) naturally aging [to provide a sheet product having high strength and improved levels of fracture toughness and resistance to fatigue crack growth].

55 ~~56~~. (Amended). In a method of producing an aluminum base alloy aircraft skin wherein an aluminum alloy product is [formed to produce] made into said aircraft skin, the improvement wherein said product is provided [as] by the method comprising:

(a) providing a body comprising an aluminum base alloy [containing] consisting essentially of about 3.8 to 4.5 wt.% Cu, 1.2 to 1.85 wt.% Mg, 0.3 to 0.78 wt.% Mn, 0.5 wt.% max. Fe, 0.5 wt.% max. Si, the remainder substantially aluminum, incidental elements and impurities;[, the product further provided in the condition resulting from:]

[(a)] (b) hot rolling said alloy to a slab [in a temperature range of 600 to 900°F];

[(b)] (c) heating said slab [to above 910°F to dissolve soluble constituents] within about 900° to 945°F;

[(c)] (d) hot rolling the slab [in a temperature range of 600 to 900°F to a sheet product];

[(d)] (e) solution heat treating [the sheet product]; and

[(e)] (f) cooling[; and

(f) naturally aging to provide a sheet product having high strength and good levels of fracture toughness and resistance to fatigue crack growth].

56 ~~57.~~ ~~(Amended)~~ In a method of producing an aluminum base alloy aircraft skin wherein an aluminum alloy sheet product is formed to produce said aircraft skin product, the improvement wherein said sheet product is provided [as] by the method comprising:

A9 cont.

(a) providing a body comprising an aluminum base alloy [containing] consisting essentially of about 3.8 to 4.5 wt.% Cu, 1.2 to 1.85 wt.% Mg, 0.3 to 0.78 wt.% Mn, 0.5 wt.% max. Fe, 0.5 wt.% max. Si, the remainder substantially aluminum, incidental elements and impurities;[, the sheet product further provided in the condition resulting from:]

[(a)] (b) hot rolling the alloy to a slab [in a temperature range of 600 to 900°F];

[(b)] (c) heating said slab [to above 910°F to dissolve soluble constituents] within 900° to 945°F;

[(c)] (d) hot rolling the slab [in a temperature in the range of 600 to 900°F to a sheet product];

(e) cold rolling;

[(d)] (f) solution heat treating [for a time of less than 15 minutes in a temperature range of 910 to 1050°F];

[(e)] (g) rapidly cooling; and

[(f)] (h) naturally aging to provide a sheet product having high strength and good levels of fracture toughness and resistance to fatigue crack growth.

57
~~58.~~ ~~(Amended)~~ In a method of producing [a damage tolerant aluminum base alloy] aircraft fuselage skin [product] from an aluminum sheet product, the improvement wherein said aluminum sheet product is provided [as] by the method comprising:

(a) providing a body comprising an aluminum base alloy [containing] consisting essentially of about 3.8 to 4.5 wt.% Cu, 1.2 to 1.85 wt.% Mg, 0.3 to 0.78 wt.% Mn, 0.5 wt.% max. Fe, 0.5 wt.% max. Si, the remainder substantially aluminum, incidental elements and impurities;[, the product further provided in the condition resulting from:]

[(a)] (b) hot rolling [said alloy in a temperature range of 600 to 900°F] to form a slab;

[(b)] (c) heating said slab [to above 910°F] within about 900° to 945°F;

[(c)] (d) further hot rolling [the slab in a temperature range of 600 to 900°F];

[(d)] (e) cold rolling to a sheet gauge having a thickness in the range of 0.05 to 0.25 inch;

[(e)] (f) solution heat treating [for a time of less than 15 minutes in a temperature range of 910 to 1050°F] within 910° to 945°F;

[(f)] (g) rapidly cooling; and

[(g)] (h) naturally aging to provide a sheet product having high strength and good levels of fracture toughness and resistance to fatigue crack growth.

REMARKS

The Examiner's thoroughness in examining this application is appreciated.

The claims have been amended to focus more clearly on certain features of the invention. Changes include "consisting essentially" in lieu of "containing" for alloy composition and a maximum of 945°F for the heating between hot rolling operations.

The Applicants' invention offers better combinations of strength and toughness and/or fatigue crack growth rate than the combinations achieved with the incumbent aircraft fuselage skin product 2024 alloy. This addresses a significant desire in the airplane construction field to improve over 2024 with a commercially viable large-scale producible product. The invention includes combinations of composition and process not heretofore realized in the art.

Section 102

Claims 1-35 and claims 52-58 were rejected under 35 U.S.C. 102(b) and (e) as being anticipated by Cho (Patent 4,816,087). For reasons set forth now, it is respectfully submitted that this rejection is incorrect and should be withdrawn.

The identity with Applicants' claims necessary to sustain a Section 102 rejection is lacking in Cho. The rejection assumes that Cho discloses processing steps for AA2024 or Al-Cu-Mg alloys, and it is respectfully submitted that this assumption is incorrect. Cho correctly and repeatedly characterizes his alloys as "aluminum lithium" alloys. For

instance, in Col. 3, line 30 et. seq., Cho refers to AA2091 setting forth its composition and emphasizes the importance of Li. Cho's alloys by definition contain more lithium than is allowable in alloy 2024. AA registration limits for alloy 2024 limit elements not listed to a maximum of .05% each. Cho's minimum for lithium is ten times that amount, and Cho's examples which revolve around alloy 2091 contain 2.11% lithium (more than 40 times the maximum permitted for alloy 2024). In fact, alloy 2091 has a registered minimum of 1.7% lithium which is around 34 times the maximum of 0.05% lithium permissible as an impurity according to the AA2024 registration composition limits. It is respectfully submitted that it is not correct to refer to Cho as disclosing processing for Al-Cu-Mg alloys or alloy 2024. This argument can be made only by ignoring most of what Cho discloses respecting the alloys Cho directs his process to. Applicants' present claims are clearly directed to Al-Cu-Mg alloys in contrast to Cho.

The mere fact that Cho's temperature ranges may overlap some of Applicants' temperature ranges does not support an argument for anticipation under Section 102. The ranges are clearly different and therefore there is no rejection appropriate under Section 102. Applicants respectfully emphasize that <u>all of Cho's preferred practices and the practices referred to in his example are clearly outside Applicants' presently claimed temperature ranges</u>.

Clearly the rejection under Section 102 should be withdrawn.

Section 103

Applicants' claims 1-64 were rejected under 35 U.S.C. 103 as being unpatentable over Cho in view of Hyatt et al. (Patent No. 4,294,625). It is respectfully submitted that this rejection is incorrect and should be withdrawn.

The rejection under Section 103 argues that Cho discloses a process for heat treating Al-Cu-Mg alloys (similar to alloy 2024). The preceding discussion above explains how Cho does not refer to alloy 2024 except as by way of contrast and really doesn't refer to Al-Cu-Mg alloy as part of its teaching since an indispensable and major element in Cho's alloy is lithium (see Col. 3, lines 40-50). That is why Cho calls its alloys "aluminum-lithium" alloys, again and again. Certainly, Cho contrasts his "Al-Li" alloy and his alloy product from 2024 and it is respectfully submitted that it is not appropriate to turn Cho around in arguing that Cho is processing Al-Cu-Mg alloys or alloys that "are similar" to 2024 since such defies Cho's express teachings which repeatedly refer to his alloy as a "lithium containing aluminum base alloy", that is, different from 2024. In Cho's claims, expressions like "aluminum-lithium product" (claims 1 and 6) and "aluminum-lithium alloy" (claim 13) make it clear as to what Cho is talking about. In fact, any reading of Cho's specification and claims makes it manifestly clear that Cho is referring only to an aluminum-lithium alloy and not an Al-Cu-Mg alloy in describing his processing. Accordingly, arguments seeking to equate or "similarize" alloy 2024 with Cho's alloy find no support in Cho and, it is respectfully argued, it

is incorrect to assume that support (1) for purposes of fashioning an argument respecting rejection of Applicants' claims or (2) for purposes of arguing any combination with Hyatt which does refer to Al-Cu-Mg alloys.

Further on the matter of Cho, Applicants do not agree that Cho discloses Applicants' properties. Applicants' claims recite a minimum K-apparent toughness of 88 ksi√in. It is true that Cho allows for higher fracture toughness than the Applicants' minimum but it is also true that Cho allows for considerably lower (for instance 60 ksi√in. toughness, col. 7, line 14). When Applicants refer to a minimum performance level for toughness in Applicants' claims, what Applicants are saying is that a toughness of 60 would not satisfy Applicants' minimum. When a minimum is established for a product, an airframe designer can utilize that minimum (subject to safety factor consideration) in redesigning an airplane. With respect, Applicants point out that a minimum is different than a wide range (below and above that minimum) and Applicants' claims refer to minimum property levels in reciting numbers for toughness or yield strength, and maximum levels for fatigue crack growth rates. Minimums and maximums are a lot different than "maybe's", and Applicants respectfully urge that attempting to equate broad disclosures as somehow suggesting Applicants' minimums and maximums is incorrect in framing an obviousness rejection. Still further, Cho does not refer to Applicants' improved fatigue crack growth rate properties.

Further with respect to Cho, it is again pointed out that while Cho's temperature ranges are indeed broadly stated, Cho's temperature teaching, taken as a whole, is quite incompatible with Applicants' selected temperatures. Applicants' revised claims specify a maximum of 945°F for Applicants' reheat temperature. Following Cho's preferred practices and examples points away from Applicants' present claims. There is no suggestion in Cho to ignore his preferred teachings let alone do so with a different alloy! It is respectfully submitted that this is a fatal flaw in framing an obviousness rejection based on Cho. There is no suggestion in Cho to use Applicants' invention; indeed Cho points in the opposite direction. Cho starts with a different alloy (an "aluminum-lithium" alloy--see all of Cho's disclosure and all of Cho's claims) and heating it at temperatures which differ from Applicants' invention. Accordingly, it is respectfully submitted that Cho is not an appropriate reference either alone or for combination with a reference such as Hyatt that does, in fact, refer to an Al-Cu-Mg alloy.

Still further, Cho's basic teaching about a duplex structure cannot be ignored in framing a rejection based on Cho alone or in combination with another reference. Why would a person who is not seeking Cho's duplex structure refer to Cho for any particular reason? Why would a person resort to Cho's processing if that person is not interested in Cho's duplex structure?

The rejection under Section 103 asserts that Hyatt's Al-Cu-Mg alloy composition ranges overlap Applicants'. It is respectfully argued that this does not form a basis for rejecting Applicants' claims. Moreover, the rejection asserted in the Office Action has not adequately explained why it would be obvious for someone to combine Cho's Al-Li alloy duplex structure processing with Hyatt's apparently conventional structure in an Al-Cu-Mg alloy. The alloys are different! The mere fact that both references seek to improve their respective different alloys by different thermal mechanical treatment alone does not suggest any combination. Any such combination of necessity requires picking this feature from one reference and combining it with that feature from the second reference with no suggestion within either reference to do so, a practice that is not appropriate in framing an obviousness rejection.

Every claim at issue, and the entire prior art, should be considered "as a whole", rather than using:

> "...selected bits and pieces from prior patents that might be modified to fit its legally incorrect interpretation of each claim as consisting of one word."

a test rejected in Panduit Corp. v. Dennison Manufacturing Co., 1 USPQ 2nd 1593, 1605 (Fed. Cir. 1987).

When extending a reference to frame a rejection under 35 USC §103, there needs to be some suggestion within the reference or within knowledge clearly present in the art for such an extension. In Ex parte Chicago Rawhide Manufacturing Co., 223 USPQ 351 (Board of Appeals, 1984), the Board reversed an

examiner's obviousness rejection based on modifications to a single reference. At page 353, the Board held:

> "The mere fact that a worker in the art could rearrange the parts of the reference device to meet the terms of the claims on appeal is not by itself sufficient to support a finding of obviousness. The prior art must provide a motivation or reason for the worker in the art, without the benefit of the appellant's specification, to make the necessary changes in the reference device. The Examiner has not presented any evidence to support the conclusion that a worker in this art would have had any motivation to make the necessary change in the [reference] device..." (Emphasis added).

What reason is shown in Cho, who says his product has toughness, to look to Hyatt's different process for a different alloy? Would Hyatt's process achieve Cho's desired duplex structure? Similarly why would Hyatt look to Cho who is talking about a different alloy? Thus, what would one find if one took Hyatt's disclosure and tried to use Cho's processing (ignoring for a moment that the person involved wasn't concerned with duplex structure)? Would that person heat to 980° as Cho recommends? It is again pointed out that the Applicants' present method claims are limited to 945°F in the reheat step and that differs substantially from Cho's teachings. Accordingly it is respectfully submitted that there is no proper basis in either Hyatt or Cho to combine the two references. It is further submitted that any such combination would point away from the Applicants' present claims unless the combination is somehow arrived at using the Applicants' specification as a road map, a procedure which has been condemned by the Court of Appeals for the Federal Circuit.

In view of the foregoing, it is respectfully argued that the rejection of Applicants' claims under 35 U.S.C. 103 is incorrect and should be withdrawn.

<u>Section 112</u>

Examiner's objections respecting claims 21 and 25 should be resolved. Claims 21 and 25 should now be satisfactory because the objected to repetition has been eliminated from claim 20, the independent claim from which claims 21 and 25 depend.

The Official Action objects to page 10 of Applicants' specification in discussing fatigue crack growth rate. It is to be appreciated that lower is better when it comes to fatigue crack growth rate and it is believed that the Examiner appreciates such, judging from Examiner's comments. The figure 2 fatigue crack growth rate for the improvement which the Examiner correctly points out is well below 10^{-4} is in a specific test showing various data points. This demonstrates the kind of improvement achievable with the invention especially when it is compared with the inferior performance of 2024-T3. It is also pointed out that as the ΔK increases, the fatigue crack growth rate also increases in tests. Accordingly, it is respectfully submitted that, taken as a whole, the description is not inadequate in that the improved material could easily satisfy a material purchasing specification requirement of a fatigue crack growth rate not to exceed 10^{-4} inches per cycle at a stress intensity of 22 or a little higher.

Applicants respectfully disagree with the rejection of claim 39 under 35 U.S.C. 112. Nonetheless, in a spirit of moving prosecution of this application forward, the Applicants have

amended claim 39 and it is believed that the claim as now written will not be objected to. Claim 39 now refers to a fatigue crack growth rate of less than 10^{-4} inch per cycle.

The rejection of claims 52 to 58 under 35 U.S.C. 112 is respectfully believed to be incorrect. The disclosure at page 6, line 11 et. seq. provides basis for the composition ranges in claims 52 to 58.

It is respectfully argued that the provisional rejection of the claims under the judicially created doctrine of obviousness type double patenting rejection should be set aside for the time being. Applicants do not necessarily concede the correctness of the rejection but would be willing to consider resolving this through mutual terminal disclaiming at the appropriate time.

Again, the Examiner's thoroughness in examining this application is appreciated and it is respectfully submitted that for the reasons set forth above the present claims are all suitable for allowance and a Notice of Allowance covering all present claims is respectfully solicited.

Respectfully submitted,

Carl R. Lippert

Attorney for Applicant(s)
Reg. No. 22313

Carl R. Lippert, Esq.
Aluminum Company of America
Alcoa Center, PA 15069
Telephone 412-337-2774
Facsimile 412-337-5959
jmm;dea

CERTIFICATE OF SERVICE

I hereby certify that on the 15th day of August, 2006, the attached **APPENDIX TO DEFENDANTS' MEMORANDUM OF LAW IN SUPPORT OF THEIR MOTION TO DISMISS** was served upon the below-named counsel of record at the address and in the manner indicated:

Frederick L. Cottrell, III, Esquire
Richards, Layton & Finger
One Rodney Square
P.O. Box 551
Wilmington, DE 19899

HAND DELIVERY

Evan R. Chesler, Esquire
Cravath, Swaine & Moore LLP
Worldwide Plaza
825 Eighth Avenue
New York, NY 10019

VIA FEDERAL EXPRESS

William G. Todd, Esquire
Greenberg Traurig, LLP
200 Park Avenue
New York, NY 10166

VIA FEDERAL EXPRESS

/s/ Tiffany Geyer Lydon

Tiffany Geyer Lydon

171219.1

Exhibit 8

SERIAL NUMBER (Series of 1987) 07/572626 | PATENT DATE | PATENT NUMBER | ABANDONED

SERIAL NUMBER	FILING DATE	CLASS	SUBCLASS	GROUP ART UNIT	EXAMINER
07/572,626	08/27/90	~~428~~ 148	693 ~~72.7A~~	111	~~SCHUMA~~ KOEHL

APPLICANTS: JOCELYN I. PETIT, NEW KENSINGTON, PA; ROBERT W. WESTERLUND, BETTENDORF, IA; EDWARD L. COLVIN, O'HARA TWP, PA.

CONTINUING DATA*******************
VERIFIED
RRK

FOREIGN/PCT APPLICATIONS**********
VERIFIED
RRK

NOTE - DISCLAIMER
The term of this patent
subsequent to ______
has been disclaimed

Foreign priority claimed / 35 USC 119 conditions met / Verified and Acknowledged	AS FILED	STATE OR COUNTRY	SHEETS DRWGS	TOTAL CLAIMS	INDEP CLAIMS	FILING FEE RECEIVED	ATTORNEY'S DOCKET NO.
☐ yes ☒ no; ☐ yes ☒ no; RRK Examiner's initials	→	PA	4	58	24	$1,582.00	

ADDRESS: ANDREW ALEXANDER
ALUMINUM COMPANY OF AMERICA
ALCOA CENTER, PA 15069

TITLE: DAMAGE TOLERANT ALUMINUM ALLOY SHEET FOR AIRCRAFT SKIN

U.S. DEPT. of COMM.- Pat. & TM Office—PTO-436L (rev. 10-

PARTS OF APPLICATION FILED SEPARATELY

NOTICE OF ALLOWANCE MAILED: July 1, 1992

PREPARED FOR ISSUE 8/13/92

Robert R. Koehler — Assistant Examiner; Docket Clerk

R. DEAN
PRIMARY EXAMINER
GROUP 110 - ART UNIT 111
Primary Examiner
1101

CLAIMS ALLOWED: Total Claims 57; Print Claim 1

DRAWING: Sheets Drwg. 4; Figs. Drwg. 4; Print Fig. 1

ISSUE FEE: Amount Due $1130.00; Date Paid

ISSUE CLASSIFICATION: Class 148; Subclass 693

ISSUE BATCH NUMBER: E26

FORM PTO-1267 U.S. DEPT. OF COMMERCE PAT. & TM OFF. (REV. 6-78)

DISCLAIMER LABEL

SERIAL NO.	FILING DATE
572,626	08/27/90

terminal disclaimer has been entered and recorded under 35 U.S.C. 253 in this file by Patent Issue Division.

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Rev. 5/89

UNITED STATES DEPARTMENT OF COMMERCE
Patent and Trademark Office
Address: COMMISSIONER OF PATENTS AND TRADEMARKS
Washington, D.C. 20231

SERIAL NUMBER	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.
07/572,626	08/27/90	PETIT	J

EXAMINER
KOEHLER, R

ANDREW ALEXANDER
ALUMINUM COMPANY OF AMERICA
ALCOA CENTER, PA 15069

ART UNIT	PAPER NUMBER
1101	11.

DATE MAILED 03/20/92

☐ This application has been examined ☒ Responsive to communication filed on 2-24-92 ☒ This action is made final.

A shortened statutory period for response to this action is set to expire 3 month(s), ~~days~~ from the date of this letter.
Failure to respond within the period for response will cause the application to become abandoned. 35 U.S.C. 133

Part I THE FOLLOWING ATTACHMENT(S) ARE PART OF THIS ACTION:

1. ☐ Notice of References Cited by Examiner, PTO-892.
2. ☐ Notice re Patent Drawing, PTO-948.
3. ☐ Notice of Art Cited by Applicant, PTO-1449.
4. ☐ Notice of Informal Patent Application, Form PTO-152.
5. ☐ Information on How to Effect Drawing Changes, PTO-1474.
6. ☐ ______

Part II SUMMARY OF ACTION

1. ☒ Claims 1 to 28 and 30 to 58 are pending in the application.

   Of the above, claims ______ withdrawn from consideration.

2. ☒ Claim~~s~~ 29 has ~~have been~~ cancelled.
3. ☐ Claims ______ are allowed.
4. ☒ Claims 1 to 28 and 30 to 58 are rejected.
5. ☐ Claims ______ are objected to.
6. ☐ Claims ______ are subject to restriction or election requirement.
7. ☒ This application has been filed with informal drawings under 37 C.F.R. 1.85 which are acceptable for examination purposes.
8. ☐ Formal drawings are required in response to this Office action.
9. ☐ The corrected or substitute drawings have been received on ______. Under 37 C.F.R. 1.84 these drawings are ☐ acceptable. ☐ not acceptable (see explanation or Notice re Patent Drawing, PTO-948).
10. ☐ The proposed additional or substitute sheet(s) of drawings, filed on ______ has (have) been ☐ approved by the examiner. ☐ disapproved by the examiner (see explanation).
11. ☐ The proposed drawing correction, filed on ______, has been ☐ approved. ☐ disapproved (see explanation).
12. ☐ Acknowledgment is made of the claim for priority under U.S.C. 119. The certified copy has ☐ been received ☐ not been received ☐ been filed in parent application, serial no. ______ ; filed on ______.
13. ☐ Since this application appears to be in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under Ex parte Quayle, 1935 C.D. 11; 453 O.G. 213.
14. ☐ Other

PTOL-326 (Rev. 6-88)

Applicants' amendments to the claims are sufficient and satisfactory for overcoming the rejections under 35 USC 102, 35 USC 103, and 35 USC 112. Applicants' remarks about those rejections are persuasive in view of the amendments to the rejected claims. However, the Examiner will not withdraw the obviousness double patenting rejections involving copending applicants 07/572,625 and 07/620,626.

Claims 1 to 28 and 30 to 58 are provisionally rejected under the judicially created doctrine of obviousness-type double patenting as being unpatentable over claims 1 to 64 of copending application Serial No. 07/572,625. Although the conflicting claims are not identical, they are not patentably distinct from each other because both applications claim similar Al-Cu-Mg alloys (overlapping elemental composition ranges and the same alloying elements), similar thermomechanical treatments of the alloys (overlapping process conditions and process steps), and similar usage of the alloys in aircraft structures (including clad aluminum alloy structures).

This is a *provisional* obviousness-type double patenting rejection because the conflicting claims have not in fact been patented.

Claims 1 to 28 and 30 to 58 are provisionally rejected under

the judicially created doctrine of obviousness-type double patenting as being unpatentable over claims 1 to 41 of copending application Serial No. 07/620,626. Although the conflicting claims are not identical, they are not patentably distinct from each other because both applications claim Al-Cu-Mg alloys with overlapping elemental composition ranges and same alloying elements, thermomechanical treatments of the alloys with overlapping process conditions and process steps, and similar usage of the alloys in aircraft structures (including clad aluminum alloy structures).

This is a *provisional* obviousness-type double patenting rejection because the conflicting claims have not in fact been patented.

The obviousness-type double patenting rejection is a judicially established doctrine based upon public policy and is primarily intended to prevent prolongation of the patent term by prohibiting claims in a second patent not patentably distinct from claims in a first patent. *In re Vogel*, 164 USPQ 619 (CCPA 1970). A timely filed terminal disclaimer in compliance with 37 C.F.R. § 1.321(b) would overcome an actual or provisional rejection on this ground provided the conflicting application or patent is shown to be commonly owned with this application. See 37 C.F.R. § 1.78(d).

THIS ACTION IS MADE FINAL. Applicant is reminded of the extension of time policy as set forth in 37 C.F.R. § 1.136(a).

A SHORTENED STATUTORY PERIOD FOR RESPONSE TO THIS FINAL ACTION IS SET TO EXPIRE THREE MONTHS FROM THE DATE OF THIS

ACTION. IN THE EVENT A FIRST RESPONSE IS FILED WITHIN TWO MONTHS OF THE MAILING DATE OF THIS FINAL ACTION AND THE ADVISORY ACTION IS NOT MAILED UNTIL AFTER THE END OF THE THREE-MONTH SHORTENED STATUTORY PERIOD, THEN THE SHORTENED STATUTORY PERIOD WILL EXPIRE ON THE DATE THE ADVISORY ACTION IS MAILED, AND ANY EXTENSION FEE PURSUANT TO 37 C.F.R. § 1.136(a) WILL BE CALCULATED FROM THE MAILING DATE OF THE ADVISORY ACTION. IN NO EVENT WILL THE STATUTORY PERIOD FOR RESPONSE EXPIRE LATER THAN SIX MONTHS FROM THE DATE OF THIS FINAL ACTION.

Any inquiry concerning this communication or earlier communications from the examiner should be directed to R. Koehler whose telephone number is (703) 308-2532.

Any inquiry of a general nature or relating to the status of this application should be directed to the Group receptionist whose telephone number is (703) 308-0661.

R. Dean

R. Koehler:rg R.R.K.
March 16, 1992

IN THE UNITED STATES DISTRICT COURT
FOR THE DISTRICT OF DELAWARE

ALCOA, INC., Plaintiff,	)	
v.	)	C.A. No. 06-383-SLR
ALCAN INC., a Canadian corporation, ALCAN CORP., a Texas corporation, ALCAN CORP., a Delaware corporation, PECHINEY, S.A., a French corporation, ALCAN RHENALU, a French corporation, ALCAN PECHINEY CORP., a Texas corporation, PECHINEY METALS, LLC, a Delaware limited liability company, ALCAN ROLLED PRODUCTS – RAVENSWOOD, LLC, a Delaware limited liability company, Defendants.	)	

APPENDIX TO DEFENDANTS' MEMORANDUM OF LAW IN SUPPORT OF THEIR MOTION TO DISMISS FOR FAILURE TO STATE A CLAIM UPON WHICH RELIEF CAN BE GRANTED

(VOLUME 2 OF 2)

ASHBY & GEDDES
Steven J. Balick (I.D. #2114)
John G. Day (I.D. #2403)
Tiffany Geyer Lydon (I.D. #3950)
222 Delaware Avenue, 17th Floor
P.O. Box 1150
Wilmington, DE 19899
sbalick@ashby-geddes.com
jday@ashby-geddes.com
tlydon@ashby-geddes.com

Counsel for Defendants

Of Counsel:

Steven R. Trybus
Donald R. Cassling
Shelley Smith
Patrick L. Patras
JENNER & BLOCK LLP
One IBM Plaza
Chicago, IL 60611

Dated: August 15, 2006

TABLE OF CONTENTS

Exhibit 9

[redacted]

MAY 25 1993

PATENT NUMBER 5213639

5213639

UMBER	FILING DATE	CLASS	SUBCLASS	GROUP ART

RRK

now abandoned.
now abandoned.
RRK
10-19-92

RRK

NOTE - DISCLAIMER
The term of this patent subsequent to ______ has been disclaimed

priority claimed ☐ yes ☒ no; 119 conditions met ☐ yes ☒ no; Acknowledged RRK Examiner's Initials	AS FILED	STATE OR COUNTRY	SHEETS DRWGS.	TOTAL CLAIMS	INDEP. CLAIMS	FILING FEE RECEIVED	ATTORNEY'S DOCKET NO.

U.S. DEPT. of COMM.-Pat. & TM Office—PTO-436L (rev. 10-78)

ISSUE FEE IN FILE

ATION

PREPARED FOR ISSUE 11-3-92		CLAIMS ALLOWED	
Robert R. Koehler Assistant Examiner	Docket Clerk	Total Claims 232	Print Claim 1
RDD PRIMARY EXAMINER ART UNIT 1101 Primary Examiner		DRAWING: Sheets Drwg. 12	Figs. Drwg. 13 / Print Fig. 5

ISSUE CLASSIFICATION			
Class 148	Subclass 693	ISSUE BATCH NUMBER	H56

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-92

1001 - 1-93

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DISCLAIMER LABEL

NO.	FILING DATE
352	03/26/92

claimer has been entered and 35 U.S.C. 253 in this file by ision.

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PTO-436 8/80

PATENT APPLICATION SERIAL NO. 07/847352

U.S. DEPARTMENT OF COMMERCE
PATENT AND TRADEMARK OFFICE
FEE RECORD SHEET

100 MG 03/16/92 07847352 1 101 5,998.00 CK

PTO-1556
(5/87)

847,352

Abstract of the Disclosure

A method of producing a sheet product and improved products having improved levels of toughness and fatigue crack growth resistance at good strength levels. The method comprises providing an aluminum base alloy containing 4 to 4.5% Cu, 1.2 to 1.5% Mg, 0.4 to 0.6% Mn, 0.12% max. Fe, 0.1% max. Si, the remainder aluminum, incidental elements and impurities and hot rolling the alloy, heating the alloy to above 910°F and additionally hot rolling it in a range of about 600 to 900°F, solution heat treating, preferably for a time of less than about 15 minutes at a solution heat treating temperature, and rapidly cooling and naturally aging. The invention products have very good combinations of strength together with high fracture toughness or low fatigue crack growth rate, or both, making them well suited for aerospace applications such as fuselage skin. The products preferably include a corrosion protecting cladding of aluminum or aluminum alloy.

#5998.00-101 A
07/847352

DAMAGE TOLERANT ALUMINUM ALLOY ~~PRODUCTS USEFUL FOR AIRCRAFT APPLICATIONS SUCH AS SKIN~~

Background of the Invention

This application is a continuation-in-part of U.S. patent application Serial Nos. 07/572,625 and 07/572,626, both of which were filed August 27, 1990, the entire contents of which are incorporated herein by reference, and both patent applications now abandoned.

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This invention relates to aluminum alloys suitable for use in aircraft applications and, more particularly, it relates to an improved aluminum alloy and processing therefor having improved resistance to fatigue crack growth and fracture toughness and suited to use as aircraft skin.

The design of commercial aircraft requires different sets of properties for different types of structures on the airplane. In many parts, resistance to crack propagation either in the form of fracture toughness or fatigue crack growth is essential. Therefore, many significant benefits can be realized by improving fracture toughness and resistance to fatigue crack propagation.

A new material with improved toughness, for example, will have a higher level of damage tolerance. On the aircraft, this translates to improved safety for passengers and crew and weight savings in the structure which allows for improved fuel economy, longer flight range, greater payload capacity or a combination of these.

Cyclic loading occurs on a commercial jet airplane with each flight as the interior of the airplane is pressurized and

then depressurized. Typically, airplanes may see up to 100,000 such pressurization cycles during their normal service lifetime. Slower rates of crack growth during cyclic loading would allow for weight savings, longer service lives (more pressurizing cycles), decreased inspection frequencies and even greater passenger safety. Thus, it will be noted that great benefit is derived from improved fracture toughness and resistance to fatigue crack growth, both of which are related to cyclic loading.

U.S. Patent 4,336,075 discloses the use of AA2000 type aluminum alloy for aircraft wings.

The present invention provides aluminum base alloy sheet products and a method of fabricating sheet products from a body of the alloy. Further, the invention provides aluminum alloy sheet products suitable for aircraft applications such as aircraft fuselage panels, which sheets are clad with a corrosion protecting outer layer. It can be envisioned that the invention can also have benefits in other areas of the aircraft where fracture toughness or fatigue crack growth resistance (or both) are important, such as lower wing skins, horizontal stabilizer, pressure bulkheads and fuselage reinforcements.

Summary of the Invention

A principal object of the invention is to provide an aluminum alloy and sheet product formed therefrom, the sheet product having improved fracture toughness and resistance to fatigue crack growth while maintaining high strength properties and corrosion resistance.

A further object of the present invention is to provide aluminum alloy sheet products having improved fracture toughness and resistance to fatigue crack growth for aircraft panels.

Yet a further object of the present invention is to provide aluminum alloy sheet products and a process for producing the sheet products so as to provide improved fracture toughness and increased resistance to fatigue crack growth while still maintaining high levels of strength.

Still a further object of the invention is to provide a method for processing an aluminum alloy into clad sheet products having improved resistance to fatigue crack growth while maintaining high strength properties and corrosion resistance.

And still a further object is to provide an Al-Cu-Mg-Mn clad sheet product for use as aircraft panels such as wing or fuselage skins having improved resistance to fatigue crack growth while maintaining high strength levels and improved fracture toughness.

These and other objects will become apparent from a reading of the specification and claims and an inspection of the claims appended hereto.

In accordance with these objects, there is provided a method of producing a sheet product having improved levels of toughness and fatigue crack growth resistance while maintaining high strength, the method comprising providing a body of an aluminum base alloy preferably containing about 4.15 to 4.5 % Cu, 1.2 to 1.45% Mg, 0.4 to 0.7% Mn, 0.1% max. Fe, 0.1% max. Si, the remainder substantially aluminum, incidental elements and

impurities. The method further comprises heating a body of the alloy to above 900°F to dissolve soluble constituents. Thereafter, the body is hot rolled in the range of about 600 to 900°F, and possibly cold rolled, and solution heat treated for a time of less than about 60 minutes, for example, at the solution heat treating temperature, then rapidly cooled (and, optionally, plastically deformed) and naturally aged to provide a sheet product with improved levels of fatigue crack growth resistance and fracture toughness while maintaining high strength levels.

Brief Description of the Drawings

Figure 1 shows fracture toughness K_C and yield strength data for improved material and for 2024.

Figure 2 is a graph showing fatigue crack growth rate data versus crack length for specially processed 2024 in the solution heat treated, cold worked and naturally aged T3 temper and for the improved product in accordance with the invention.

Figure 2a is a plot of the ratio of the fatigue crack growth rate for the improvement divided by that for 2024 versus ΔK.

Figure 3 is a differential scanning calorimetry curve of 2024-T3.

Figure 4 is a differential scanning calorimetry curve of an aluminum alloy product in accordance with the invention.

Figure 5 shows fracture toughness and yield strength data for different sheet materials from Example 2 hereof.

Figure 6 shows fracture toughness and yield strength data for sheet products of the invention and for 2024-T3.

Figure 7 shows fatigue crack propagation rate versus change in crack length for the invention product and for 2024-T3.

Figures 8, 8a and 8b are plots of maximum fatigue crack growth rate versus ΔK for the constant load test.

Figure 9 plots maximum fatigue crack growth rate versus ΔK for the constant ΔK test.

Figure 10 plots fatigue crack growth rate versus ΔK for different relative humidity levels (95% humidity and ordinary ambient).

Detailed Description of the Preferred Embodiments

Typically, the alloy of the present invention preferably comprises about 3.8 or 3.9 or 4 to 4.5% Cu, 1.2 or 1.3 to 1.5 or 1.6% Mg, 0.4 to 0.8% Mn, 0.01 or 0.02 to 0.1 or 0.15% Fe, 0.01 or 0.02 to 0.1 or 0.15% Si, the balance aluminum, incidental elements and impurities. Unless indicated otherwise, all percentages for alloy elements herein are weight percent.

A preferred alloy would contain about 4.1 to 4.4% Cu, about 1.2 to 1.45% Mg, about 0.4 to 0.7% Mn, Fe not exceeding about 0.1 or 0.15%, for instance about 0.01 or 0.02 to 0.12 or 0.15% Fe, Si not exceeding about 0.1 or 0.15% maximum, for instance about 0.01 or 0.02 to 0.1 or 0.12% Si, the balance essentially aluminum, incidental elements and impurities. Impurity element Zn preferably has a maximum of 0.2 or 0.25% and Cr a maximum of 0.1 or possibly 0.2%. Zr could be added up to 0.5% Zr, with a range for Zr being 0.05 to 0.15 or 0.2 or 0.25%, such as if it is desired to make an unrecrystallized product such as a product wherein no more than 20 or 25 vol.% of the product

is recrystallized. At levels of Zr above about 0.12%, coarse primary Zr-bearing particles might be formed in casting and these can be detrimental to toughness, unless care is taken to avoid such. Impurities are preferably limited to 0.05% each and the combination of impurities preferably should not exceed 0.15%. The sum total of incidental elements and impurities preferably does not exceed 0.25%, although in some cases incidental elements such as V, Hf, Cr, Ag or Sc can be included in amounts of up to about 0.5 or 1%, for instance 0.05 to 0.1 or 0.2%. A typical alloy composition would contain about 4.25% Cu, 1.35% Mg, 0.5% Mn, 0.12% max. Fe and 0.1% max. Si with Fe plus Si not totaling more than 0.20 and preferably not more than 0.15.

Mn contributes to or aids in grain size control during operations that can cause the metal to recrystallize. Very large grains are detrimental to properties such as fracture toughness, formability and corrosion resistance.

Fe and Si are normally considered impurities in aluminum and in practicing the invention their levels are preferably kept relatively low to limit formation of the constituent phases Al_7Cu_2Fe and Mg_2Si which are detrimental to fracture toughness and fatigue crack growth resistance. These phases have low solid solubility in Al-alloy and once formed cannot be eliminated by thermal treatments. Formation of Al_7Cu_2Fe and Mg_2Si phases can also lower the strength of the product because their formation reduces the amount of Cu and Mg available to form strengthening precipitates. A decrease in Fe and Si increases toughness and resistance to fatigue crack growth. Thus, in the present

invention, it is preferred to control Fe to below 0.1 or 0.15% and Si to below 0.1 or 0.15%, at least where large direct chill (DC) casting is used to make the alloy ingot. Spray casting or other ingot producing techniques may make higher amounts of Fe and Si more tolerable such as 0.2% or 0.3% or 0.4% Fe or Si, or even 0.5% of each.

Preferably, Cu and Mg are carefully controlled to maintain good strength while providing the benefits in toughness and fatigue. The Cu and Mg levels should be low enough to allow for dissolution of the slightly soluble Al_2CuMg and Al_2Cu constituent phases during high temperature processing yet high enough to increase or maximize the amount of free Cu and Mg available to adequately strengthen the alloy.

The following equations may be used to estimate the "free Cu" and "free Mg"; that is, the amount of Cu and Mg that are available to form strengthening phases.

$$Cu_{Free}=Cu_{Total}-2.28Fe-0.74(Mn-0.2)$$

$$Mg_{Free}=Mg_{Total}-1.73(Si-0.05)$$

As well as providing the alloy product with controlled amounts of alloying elements as described herein, it is preferred that the alloy be prepared according to specific method steps in order to provide the most desirable characteristics of both strength, fracture toughness, corrosion resistance and resistance to fatigue crack growth as required, for example, for use as aircraft skins or panels. The alloy as described herein can be provided as an ingot or slab for fabrication into a suitable wrought product by casting techniques currently employed in the

art for cast products with continuous casting being preferred. Slabs resulting from belt casters or roll casters also may be used. Alternately, the alloy can be spray cast into the ingot or slab wherein liquid metal drops are solidified against solidified ingot or stock.

In a broader aspect of the invention, the alloy consists essentially of about 3.8 to 4.5% Cu, 1.2 to 1.85% Mg, 0.3 to 0.78 or 0.8 or 0.9% Mn, 0.5 wt.% max. Fe, 0.5% Si, the balance aluminum, incidental elements and impurities.

The ingot or slab of the alloy of the invention may be provided with a cladding on either or both sides thereof and this composite is then processed in accordance with the invention. Such clad or composite products utilize a core of the aluminum base alloy of the invention and a cladding typically of higher purity alloy which corrosion protects the core. The cladding includes essentially unalloyed aluminum or aluminum containing not more than 0.1 or 1% of all other elements. Aluminum alloys herein designated 1XXX type refer to all Aluminum Association (AA) alloys having the number 1 as the first digit and thus include all 1000 types, 1100 types, 1200 types and 1300 types. It also is intended to encompass all other aluminum or aluminum base compositions that satisfy the AA registered composition limits for any AA alloy having 1 as the first digit in its AA designation. In general, 1XXX type aluminum or aluminum alloy can serve as the cladding. Thus, the cladding on the core may be selected from various Aluminum Association alloys such as 1060, 1045, 1100, 1200, 1230, 1135, 1235, 1435, 1145, 1345, 1250, 1350,

1170, 1175, 1180, 1185, 1285, 1188 or 1199. In addition, AA alloy 7072 containing zinc (0.8 to 1.3) can serve as the cladding and alloys such as 6003 or 6253 which contain more than 1% of alloying additions can serve as cladding. The cladding alloy is different than the core alloy and does not contain as much copper, preferably being free of substantial amounts of copper, not over 0.5 or 1%, preferably less than 0.2 or 0.3% Cu, which could interfere with corrosion protection. Other alloys could also be useful as cladding as long as they provide sufficient overall corrosion protection to the core alloy. The clad layer or layers are much thinner than the core, each constituting 1 to 15 or 20 or possibly 25% of the total composite thickness. A cladding layer more typically constitutes around 1 to 10% or so of the total composite thickness.

In addition to or in lieu of an aluminum or aluminum alloy cladding, a chemical, electrochemical or other coating or surface treatment can be used to improve corrosion resistance if desired, although cladding is presently preferred.

The alloy stock may be homogenized prior to hot working or it may be heated and directly hot rolled. If homogenization is used, it may be carried out by heating to a metal temperature in the range of 900° or 910° or 920°F to 945° or 950° or 960°F or, possibly as much as 1000°F, for a period of time of at least 1 hour to dissolve soluble elements and to homogenize the internal structure of the metal. It is to be understood that temperatures substantially above 945° or 950° or 960°F, for instance a temperature of 975° or 980° or 1000°F, introduce

significant risk of damaging the metal and are preferably avoided. A suitable time period is about 4 hours or more in the homogenization temperature range. Normally, the soak time at the homogenizing temperature does not have to extend for more than 8 hours, however, longer times are not normally detrimental. Four to six hours at the homogenization temperature has been found to be quite suitable. A typical homogenization temperature is 920°F.

For purposes of the present invention, it can be preferred to initially hot roll a clad ingot composite without a full homogenizing. Thus, the ingot can be heated to 800° or 850° to 900° or 950°F for a short time (or to 900° to 950°F for a longer time in the case of homogenization) and hot worked or hot rolled to provide an intermediate gauge product, typically a slab. Hot rolling is performed wherein the starting temperature for rolling is in the range of 600 to 900°F, or even possibly higher provided melting or other ingot damage is avoided. When the use of the alloy is for fuselage skins, for example, the hot rolling is typically performed on ingot or starting stock 15 to 20 or more inches thick to provide an intermediate product or slab having a thickness of about 2 or 3 to 8 inches, the typical reductions being 40 or 50 or 60% to about 80% or more.

After hot rolling, the intermediate gauge product or slab is subjected to a reheating step. This reheating step is quite important to the present invention, particularly with respect to minimizing or avoiding soluble constituent or secondary phase particles and improving fatigue crack growth resistance and fracture toughness. Thus, in the reheating step,

the intermediate gauge product or hot rolled slab is heated to a temperature of at least about 900°, or possibly a lower temperature such as 895° or maybe 890° on a somewhat less preferred basis, to a temperature of about 920° or 930°F, for example, which is near or above the solvus temperature of secondary phase particles, to dissolve or partially dissolve soluble constituents that remain from casting or may have precipitated during the preceding hot rolling. Such constituent particles include Al_2CuMg, Al_2Cu, for example. The reheating has the effect of putting most of the Cu and Mg into solid solution. The heating can be in the range of 900 to 945°F, or possibly 950° or possibly as much as 960°F, with a preferred range being 900 or 910 to 930°F or 940°F. It is repeated that temperatures substantially above 945° or 950°F introduce risk of damaging the metal and decreasing the advantages achieved in practicing the invention, it being added that the reheating operation is even less tolerant of excessive temperature than homogenization or heating before the first hot rolling. A reheating temperature of 975° or 980°F could damage the metal because non-equilibrium eutectic melting would initiate or occur. Hence, such excessive temperatures are preferably avoided in practicing the invention, especially in both the reheat step and in subsequent operations such as solution heat treating where maximum temperatures are preferably limited to about 950° or 955°F, and more preferably, do not exceed 940° or 945°F, better yet not over 935°F, especially for metal which is derived from large DC cast ingots which can contain pockets having richer concentrations of

alloying elements such as copper, a condition which might be relieved some by spray casting or other ingot production techniques. In the reheating operation, the intermediate gauge product can be held for about 20 minutes (or possibly 10 minutes) or one half or 1 hour to about 40 hours when the metal is in the aforesaid temperature range or near or above the solvus temperature for the soluble elements or phases. Preferably, times at said metal temperature of 900°F or more are more than 2 hours, for instance in the range of 3 or more, preferably 4 hours or more to about 24 hours for metal derived from DC casting. It is important that the reheat is carefully controlled within the parameters set forth. If the reheating operation is substantially lower than 900°F, for example, 850°F, this can leave large volumes of coarse undissolved Al_2CuMg and Al_2Cu particles, for example, which particles can have an adverse effect on the fatigue crack growth resistance in the final product. In fact, if the reheat is below the solvus temperature, these particles can even grow in size. The presence of such particles can limit crack propagation resistance in the final sheet product.

In clad products, the temperature and duration of the reheat is very important for another reason. If the reheat temperature is excessive or if the time at reheat temperature is excessive, copper can diffuse into the higher purity aluminum cladding. This diffusion can detrimentally affect the corrosion protection afforded by the cladding. The present invention serves to both increase the dissolution of the deleterious

constituent particles and yet avoid excessive high temperature thermal exposure times that can cause copper diffusion into the cladding, or at least keep diffusion within acceptable levels.

After the reheat, the intermediate product or slab is subjected to a second hot rolling operation. The second hot rolling operation is performed in the temperature range of about 500 to 900°F, preferably 600 to 850°F. In general, this is effected by moving the metal from the reheating furnace to the rolling station without the need for a separate cooling operation which could even be harmful if it involved substantial times at temperatures within 800° or 820° to 870° or 880°F. The hot rolling may be performed to a final gauge, e.g., 0.5 inch or less. Alternatively, the hot rolling step can be performed to provide a second intermediate product, typically sheet, having a thickness in the range of 0.1 to 0.25 or 0.3 inch or more. Thereafter, the second intermediate product can be cold rolled to a final gauge typically in the range of 0.01 or 0.05 to about 0.2 inch, but possibly up to about one-half inch, to produce a substantially or largely recrystallized product. An intermediate anneal may be used before cold rolling, if desired. Alternatively the product can be hot rolled to a final thickness of 0.1 or 0.2 or 0.3 inch or up to about 1/2 inch or a little more such as up to around 5/8 inch without cold rolling.

Even though hot rolling can proceed within 600° to 900°F, once the reheat step is performed effort preferably should be made to avoid prolonged exposure to temperatures substantially above 700° or 750°F and substantially below around 900°, for

instance temperatures around 850° or even 800°F should be avoided for prolonged exposures although the relatively brief exposures encountered in hot rolling are not considered excessive. Such temperatures (for instance around 800° or 825° to 875°F or so), if encountered for substantial time, result in lowered toughness and higher fatigue crack growth rate. Hence, the practice of the invention preferably includes measures consistent with plant practicalities and economics to avoid substantial time exposures (for example exceeding about 3 to 1 hour) at temperatures of about 780° or 800° or more to 870° or so, after the aforesaid reheating step (at 900 or 910° to about 945 or 950°F) used in practicing the invention.

After rolling, the sheet product is subjected to a solution heat treatment preferably in the range of about 900° or 910° to 945° or 950°F, more preferably 905° to 935° or 940°F. It can be important that the solution heat treatment be carefully controlled in duration. Thus, the solution heat treatment can be accomplished in 5 minutes or even less when the metal has reached the solution temperature. The time can be extended to 15 minutes or even 60 minutes or possibly longer especially with a non-clad product. However, in clad product, care should be taken against diffusion of copper into the cladding and possible problems resulting therefrom and shorter times favor less diffusion.

Solution heat treatment in accordance with the present invention may be performed on a continuous basis. Basically, solution effects can occur fairly rapidly. In continuous treating, the sheet is passed continuously as a single web

through an elongated furnace which greatly increases the heat-up rate. Long solution heat treat times may be used to dissolve the soluble constituents such as Al_2CuMg and Al_2Cu. However, long time (more than 1 hour or 2 hours) solution heat treatments should not be used on clad products because of the excessive Cu diffusion that can occur in the cladding. The continuous approach facilitates practice of the invention since a relatively rapid heat-up and short dwell time at solution temperature result in minimizing copper diffusion into the cladding. Accordingly, solution heat treating in as little as about 10 minutes, or less, for instance about 0.5 to 4 minutes, are useful in practicing the invention, especially for thin members with thin cladding. As a further aid to achieving a short heat-up time, a furnace temperature or a furnace zone temperature significantly above the desired metal temperatures provides a greater temperature head useful to speed heat-up times.

After solution heat treatment, it is important that the metal be rapidly cooled, or quenched, to prevent or minimize the uncontrolled precipitation of secondary phases, e.g., Al_2CuMg and Al_2Cu. Thus, it is preferred in the practice of the invention that the quench rate be at least 100°F/sec from solution temperature to a temperature of 350°F or lower. A preferred quench rate is at least 300°F/sec in the temperature range of 925°F or more to 350°F or less. Suitable rates can be achieved with the use of water, e.g., water immersion or water jets. Further, air or air jets may be employed.

After quenching, the sheet may be cold worked, for example, by stretching or cold rolling, or both, by up to about 10% of its original length. Typically, cold or other working may be employed which produces a working effect similar to (or substantially, i.e. approximately, equivalent to) that which would be imparted by stretching at room temperature in the range of about 1/2% or 1% or 1 1/2% to 2% or up to 4 or 6% or 8% of the products' original length. Stretching or other cold working such as cold rolling about 2 or 3 to 9 or 10%, preferably about 4 or 5% to about 7 or 8%, can improve strength while retaining good toughness. Yield strength can be increased around 10 ksi, for instance to levels as high as around 59 or 60 ksi or more without excessively degrading toughness, even actually increasing toughness by 5 or 6 ksi√in (K_C in L-T orientation), in one test by stretching 6 or 7%. The invention in heavy sheet form, for instance, about 0.2 or 0.25 inch thick, can be stretched 6 or 7% with relative ease and gain about 10 ksi strength along with a toughness gain of about 5 or so ksi√in, or at least no degradation in toughness, or an acceptable relatively small degradation in toughness, the strength gain being significant. Cold working before aging is easier because the metal is weaker but can encounter Leuder's lines if stretching is used. Cold working after significant aging effect (for instance, a significant strength increase) requires more power because the metal is stronger but involves less likelihood of Leuder's lines or the like.

After rapidly quenching, and cold working if desired, the sheet product is aged, preferably naturally aged. By natural aging is meant to include aging at room temperature, for instance 75°F or so, or 70° to 80°F or so, and temperatures up to around 175°F or 200°F. Aging at room temperature (75°F) reaches 90% or so of its practical naturally aged strength potential within about 24 or 30 hours or so. If cold work is employed, it can precede natural aging or follow some amount thereof as stated above. Artificial aging practices which do not excessively reduce fracture toughness or fatigue crack growth resistance could also be used. For instance, aging at around 200° to 215° or 220°F or so for 12 to 8 hours or so, or at around 280° to 300°F or so for around an hour or so could be suitable. However, excessive combination of aging time and temperature could increase strength at an excessive penalty in toughness or fatigue resistance, or both.

If artificial aging is employed, it is believed such could be combined with a forming or shaping operation. Such age forming using a load at elevated artificial aging temperature to bend or otherwise plastically form a shaped or partially shaped product is believed to be useful in practicing the invention although excessive aging time or temperature should be avoided as stated just above. Accordingly, the invention includes combining forming and artificial aging although the toughness and fatigue crack growth rate properties could be diminished some by such. Nonetheless, it is believed that the invention products would substantially outperform age formed 2024 products with respect to

the property combinations discussed herein, good combinations of strength, along with toughness or fatigue crack growth resistance, or both.

The improved product could be provided to a user in a non-solution heat treated condition, such as annealed "O" temper, and then formed and solution heat treated and aged by the user.

Conforming to these controls and using the alloy composition of the invention greatly aids the production of sheet stock having high yield strength, similar to 2024 in T3 temper, along with substantially improved levels of fracture toughness and increased resistance to fatigue crack growth and high resistance to corrosion. The above-described controls for heating and rolling impart a substantial improvement in combination with the herein-described composition controls. That is, sheet can be produced having a minimum long transverse yield strength of about 37 or 38 ksi or 39 or 40 or 42 ksi, for instance about 43 or 44 ksi or 45 or 46 or 47 ksi, along with good minimum (guaranteeable) K_c fracture toughness or good maximum (guaranteeable) fatigue crack growth rate, or both. A long transverse yield strength over 55 ksi can be achieved if the product is cold worked, such as by stretching, after quenching. Minimum yield strength could increase to 50 ksi or more, for instance 52 or 54 ksi or more, if cold working is used after quenching.

When referring to a minimum (for instance for strength or toughness) or to a maximum (for instance for fatigue crack growth rate), such refers to a level at which specifications for

materials can be written or a level at which a material can be guaranteed or a level that an airframe builder (subject to safety factor) can rely on in design. In some cases, it can have a statistical basis wherein 99% of the product conforms or is expected to conform with 95% confidence using standard statistical methods.

Figures 1 and 2 illustrate the extent of improvement in K_C toughness (Figure 1) and fatigue crack growth rate (Figure 2) of the invention over 2024 type alloy in T3 temper. Alloy 2024 is the present fuselage alloy for airliners. Figure 1 includes a point (X within square) showing 2024 that had been processed according to the process of the invention. Figure 2 shows the invention product versus 2024 that had been processed according to the invention method which enhanced its fatigue performance somewhat. The extent of the improvement for the invention is pronounced, even over 2024 that had been subjected to improved processing in accordance with the invention.

Fracture toughness is an important property to airframe designers, particularly if good toughness can be combined with good strength. By way of comparison, the tensile strength, or ability to sustain load without fracturing, of a structural component under a tensile load can be defined as the load divided by the area of the smallest section of the component perpendicular to the tensile load (net section stress). For a simple, straight-sided structure, the strength of the section is readily related to the breaking or tensile strength of a smooth tensile coupon. This is how tension testing is done. However,

for a structure containing a crack or crack-like defect, the strength of a structural component depends on the length of the crack, the geometry of the structural component, and a property of the material known as the fracture toughness. Fracture toughness can be thought of as the resistance of a material to the harmful or even catastrophic propagation of a crack under a tensile load.

Fracture toughness can be measured in several ways. One way is to load in tension a test coupon containing a crack. The load required to fracture the test coupon divided by its net section area (the cross-sectional area less the area containing the crack) is known as the residual strength with units of thousands of pounds force per unit area (ksi). When the strength of the material as well as the specimen are constant, the residual strength is a measure of the fracture toughness of the material. Because it is so dependent on strength and geometry, residual strength is usually used as a measure of fracture toughness when other methods are not as useful because of some constraint like size or shape of the available material.

When the geometry of a structural component is such that it doesn't deform plastically through the thickness when a tension load is applied (plane-strain deformation), fracture toughness is often measured as plane-strain fracture toughness, K_{Ic}. This normally applies to relatively thick products or sections, for instance 0.6 or 0.75 or 1 inch or more. The ASTM has established a standard test using a fatigue pre-cracked compact tension specimen to measure K_{Ic} which has the units

ksi√in. This test is usually used to measure fracture toughness when the material is thick because it is believed to be independent of specimen geometry as long as appropriate standards for width, crack length and thickness are met. The symbol K, as used in K_{Ic}, is referred to as the stress intensity factor. A narrower test specimen width is sometimes used for thick sections and a wider test specimen width for thinner products.

Structural components which deform by plane-strain are relatively thick as indicated above. Thinner structural components (less than 0.6 to 0.75 inch thick) usually deform under plane stress or more usually under a mixed mode condition. Measuring fracture toughness under this condition can introduce variables because the number which results from the test depends to some extent on the geometry of the test coupon. One test method is to apply a continuously increasing load to a rectangular test coupon containing a crack. A plot of stress intensity versus crack extension known as an R-curve (crack resistance curve) can be obtained this way. The load at a particular amount of crack extension based on a 25% secant offset in the load vs. crack extension curve and the crack length at that load are used to calculate a measure of fracture toughness known as K_{R25}. It also has the units of ksi√in. ASTM E561 (incorporated by reference) concerns R-curve determination.

When the geometry of the alloy product or structural component is such that it permits deformation plastically through its thickness when a tension load is applied, fracture toughness is often measured as plane-stress fracture toughness. The

fracture toughness measure uses the maximum load generated on a relatively thin, wide pre-cracked specimen. When the crack length at the maximum load is used to calculate the stress-intensity factor at that load, the stress-intensity factor is referred to as plane-stress fracture toughness K_c. When the stress-intensity factor is calculated using the crack length before the load is applied, however, the result of the calculation is known as the apparent fracture toughness, K_{app}, of the material. Because the crack length in the calculation of K_c is usually longer, values for K_c are usually higher than K_{app} for a given material. Both of these measures of fracture toughness are expressed in the units ksi√in. For tough materials, the numerical values generated by such tests generally increase as the width of the specimen increases or its thickness decreases.

Plane-stress fracture toughness can be determined from a center cracked tension test. In this test, sheet in accordance with the invention exhibits a minimum K_{app} of about 80 to 85 ksi√in, preferably 85 to 90 or 95 or more, even 100 or more, ksi√in (that is, 80 or more up to 100 or more ksi√in) when tested with an approximately 16-inch wide test specimen, and a minimum K_c within about 140 to 145, preferably within about 150 to 160 ksi√in or more, even 165 or more (that is, 140 or more up to 165 or more ksi√in). It is to be appreciated that the width of the test panel used in a toughness test can have a substantial influence on the stress intensity measured in the test. A given material may exhibit a K_{app} toughness of 60 ksi√in using a 6-inch wide test specimen, whereas for wider specimens the measured K_{app}

will increase with wider and wider specimens. For instance, the same material that had a 60 ksi√in K_{app} toughness with a 6-inch panel could exhibit a higher K_{app}, for instance arund 90 ksi√in, in a 16-inch panel and still higher K_{app}, for instance around 150 ksi√in, in a 48-inch wide panel test and a still higher K_{app}, for instance around 180 ksi√in, with a 60-inch wide panel test specimen. Accordingly, in referring to K values for toughness tests herein, unless indicated otherwise, such refers to testing with a 16-inch wide panel. However, those skilled in the art recognize that test results can vary depending on the test panel width and it is intended to encompass all such tests in referring to toughness. Hence, toughness substantially equivalent to or substantially corresponding to a minimum value for K_c or K_{app} in characterizing the invention products, while largely referring to a test with a 16-inch panel, is intended to embrace variations in K_c or K_{app} encountered in using different width panels as those skilled in the art will appreciate. It should be noted that toughness of prior commercially produced 2024-T3 alloy was not normally guaranteed or even routinely required to be tested; however, typical K_c values (from 16" wide specimen) for conventional 2024-T3 are generally about 125 ksi√in, but K_c values (T-L orientation) as low as 115 ksi√in and even below 110 ksi√in have been measured, all of which are well below 140 to 165 ksi or more for the minimum K_c for the invention product. Typical K_{app} values for 2024 using 16-inch wide test specimens are in the 70's (ksi√in) or possibly higher, but well below the levels reached with the invention. The plane-stress fracture

toughness (K_{app}) test applies to all thicknesses of products but may in some applications find more use in thinner products such as 1 inch or 3/4 inch or less in thickness, for example, 5/8 inch or 1/2 inch or less in thickness. The specimens for the immediately preceding tests are usually in the T-L orientation (specimen length perpendicular to rolling direction and crack parallel to the rolling direction). The testing typically is in accordance with ASTM E561 and ASTM B646 (both incorporated herein by reference).

The toughness of the improved products according to the invention is so high that it allows the aircraft designer's focus for a material's damage tolerance to switch some from toughness measurement to fatigue crack growth rate which, in its own right, is an important property. Resistance to cracking by fatigue is a very desirable property. The fatigue cracking referred to occurs as a result of repeated loading and unloading cycles, or cycling between a high and a low load such as when a wing moves up and down or a fuselage swells with pressurization and contracts with depressurization. The loads during fatigue are below the static ultimate or tensile strength of the material measured in a tensile test and they are typically below the yield strength of the material. If a crack or crack-like defect exists in a structure, repeated cyclic or fatigue loading can cause the crack to grow. This is referred to as fatigue crack propagation. Propagation of a crack by fatigue may lead to a crack large enough to propagate catastrophically when the combination of crack size and loads are sufficient to exceed the material's

fracture toughness. Thus, an increase in the resistance of a material to crack propagation by fatigue offers substantial benefits to aerostructure longevity. The slower a crack propagates, the better. A rapidly propagating crack in an airplane structural member can lead to catastrophic failure without adequate time for detection, whereas a slowly propagating crack allows time for detection and corrective action or repair.

The rate at which a crack in a material propagates during cyclic loading is influenced by the length of the crack. Another important factor is the difference between the maximum and the minimum loads between which the structure is cycled. One measurement including the effects of crack length and the difference between maximum and minimum loads is called the cyclic stress intensity factor range or ΔK, having units of ksi√in, similar to the stress intensity factor used to measure fracture toughness. The stress intensity factor range (ΔK) is the difference between the stress intensity factors at the maximum and minimum loads. Another measure affecting fatigue crack propagation is the ratio between the minimum and the maximum loads during cycling, and this is called the stress ratio and is denoted by R, a ratio of 0.1 meaning that the maximum load is 10 times the minimum load.

The fatigue crack propagation rate can be measured for a material using a test coupon containing a crack. One such test specimen or coupon is about 12 inches long by 4 inches wide having a notch in its center extending in a cross-wise direction (across the width; normal to the length). The notch is about

0.032 inch wide and about 0.2 inch long including a 60° bevel at each end of the slot. The test coupon is subjected to cyclic loading and the crack grows at the end(s) of the notch. After the crack reaches a predetermined length, the length of the crack is measured periodically. The crack growth rate can be calculated for a given increment of crack extension by dividing the change in crack length (called Δa) by the number of loading cycles (ΔN) which resulted in that amount of crack growth. The crack propagation rate is represented by $\Delta a/\Delta N$ or 'da/dN' and has units of inches/cycle. The fatigue crack propagation rates of a material can be determined from a center cracked tension panel. The fatigue crack propagation rates for sheet in accordance with the invention are much slower than the prior 2024-T3 alloy sheet made by standard production methods when measured using a center cracked tension panel and tested at cyclic stress intensity factors of ΔK greater than 5 ksi$\sqrt{\text{in}}$. Figure 2a shows the fraction obtained by dividing the fatigue crack propagation rate of sheet according to the invention by the fatigue crack propagation rate of 2024-T3 alloy sheet, which fraction is plotted versus the cyclic stress intensity factor range, ΔK. In Figure 2a, a ratio of 1 indicates equal fatigue crack growth rate whereas a ratio of 0.5 indicates much superior performance (half the crack growth rate, or twice as good). The data show that the fatigue crack propagation rates of the invention product sheet are dramatically reduced when compared to 2024-T3 sheet especially at higher values of ΔK. For example, at ΔK=25 ksi$\sqrt{\text{in}}$, the fatigue crack propagation rate of the sheet according to the

invention is less than one half of the crack propagation rate of 2024-T3 alloy sheet. That is, a crack in 2024-T3 alloy sheet will grow more than twice as fast as a crack in the invention product sheet when subjected to loads such that the cyclic stress intensity factor range ΔK is 25 ksi√in. At ΔK=30 ksi√in, the fatigue crack growth rate for sheet according to the invention is substantially less than 40% of the crack growth rate for 2024-T3; that is, fatigue cracks in 2024 grow two-and-a-half (2-1/2) times faster than in the invention sheet.

In a constant load amplitude test, the tensile load or pull loads for high load and low load are the same through the fatigue cycling. This causes the ΔK level in terms of stress intensity (ksi√in) to increase as the crack grows during the test. This increase becomes more rapid as the test progresses, and the precision can thereby suffer in later stages as the crack grows significantly in length.

Still another technique in testing is use of a constant ΔK gradient. In this technique, the otherwise constant amplitude load is reduced toward the latter stages of the test to slow down the rate of ΔK increase. This adds a degree of precision by slowing down the time during which the crack grows to provide more measurement precision near the end of the test when the crack tends to grow faster. This technique allows the ΔK to increase at a more constant rate than achieved in ordinary constant load amplitude testing.

Another way to measure fatigue crack propagation rate of sheet is by growing a crack at a constant level of the applied

stress intensity factor range, ΔK, throughout the test. The advantage of the constant ΔK test is that it provides a repeated measure of the crack growth rate at that level of ΔK for a relatively large distance of crack propagation. In this test, as the crack grows the tensile loads between which the panel is cycled need to be reduced as the test progresses to maintain a constant level of ΔK. At the start of this test, an initial fatigue crack is grown from a small machined slot in the center of the panel at a low value of ΔK, then the load is increased to give the desired level of ΔK. When this is done, the crack propagates at an initial rate followed by a rapid decrease to a "steady state" crack propagation rate which normally is the propagation rate measured in the test. One reason for this decrease in propagation rate is believed to be the development of what is referred to as crack closure. Crack closure can occur during the unloading portion of the fatigue cycle when the crack faces come into contact with one another before the load drops to the minimum load level. Because the crack closes at a load above the minimum load, further unloading has no effect on the crack. Thus, the difference between the minimum and maximum loads which affect the crack is reduced which results in a lower effective ΔK than the intended or nominal applied ΔK. As a consequence, when crack closure occurs, the crack growth rate of the material is decreased. Several causes of closure are rough fracture surfaces that do not fit back together exactly during unloading, oxide buildup on the fracture surfaces that come into contact during unloading, or material at the crack tip is stretched past the

yield strength (or plastically deformed) and after the crack grows through the stretched material the crack faces come into contact during unloading because the material is stretched. The latter cause is referred to as plasticity induced closure and is the cause of the initial decrease in crack growth rate observed in the constant ΔK test. After the crack has grown for some distance at a constant ΔK the amount of crack closure becomes constant and a steady state crack growth rate results.

When the invention product sheet is tested using a 4-inch wide panel with a center crack at a constant level of the cyclic stress intensity factor range of ΔK=25 ksi√in, a stress ratio of R=+0.1, in air with a relative humidity greater than 95%, the average steady state fatigue crack propagation rate for sheet according to the invention is 5.54×10^{-5}, while for commercial 2024-T3 sheet tested under the same conditions the average fatigue crack propagation rate is almost twice as fast at 10.6×10^{-5}. Similarly when tested at a constant cyclic stress intensity factor range of ΔK=30 ksi√in and the same conditions as above, the average steady state fatigue crack propagation rate for the invention sheet is 9.55×10^{-5} and for 2024-T3 sheet the average fatigue crack propagation rate is more than twice as fast at 21.4×10^{-5}. At ΔK of about 22 ksi√in, the sheet according to the invention had an average steady state fatigue crack propagation rate of 5×10^{-5} which was around half that for commercial 2024-T3 sheet. The specimens for the immediately preceding tests are usually in the T-L orientation. The testing

is in accordance with ASTM E647-88, the entire content of which is incorporated herein by reference.

As shown in Figure 2, the new product has very good resistance to fatigue crack propagation in tests conducted using a constant cyclic stress intensity factor range of 22 ksi√in. This cyclic stress intensity factor range is important for the damage tolerant design of transport airplanes such as commercial airliners, but a ΔK of 25 or 30 is also important in testing fatigue crack growth rate for aircraft application. Incidentally, in plots like Figure 2 wherein crack length is shown on the horizontal axis and *da/dN* on the vertical axis, it is common for the data points on the extreme left (near the vertical axis) representing the rate at the early stage of testing to be higher than the steady state data shown in Figure 2. The steady state data is often that of more importance.

Example 1

This example includes two parts. In Part 1, a 16 x 60 inch ingot containing, in accordance with the invention, 4.28% Cu, 1.38% Mg, 0.50% Mn, 0.07% Fe, 0.05% Si, balance Al was cast. The metal was clad with AA1145 then heated to approximately 875°F and hot rolled to a slab gauge of 4.5 inches. The rolled slab was then heated to a temperature above 910°F for 17 hours and hot rolled to a gauge of 0.176 inch. The metal was cold rolled to a final gauge of 0.100 inch before solution heat treating for 10 minutes at 925°F, quenched by cold water sprays, and stretched around 2%. The sheet was aged for 3 weeks at room temperature.

In Part 2, for comparison, an alloy with 2024 composition, 2024 being the alloy currently used for the fuselage skins of commercial jet airliners, having the approximate composition 4.6% Cu, 1.5% Mg, 0.6% Mn, 0.2% Fe, 0.1% Si, balance Al (actual composition: 4.54% Cu, 1.52% Mg, 0.64% Mn, 0.17% Fe, 0.08% Si), was processed essentially the same. It is to be noted that the 2024 comparison product does not represent typical commercial 2024 because the comparison product received processing according to the invention.

The product of the invention had a 16% higher plane stress fracture toughness (K_c=156.5 ksi√in average for 2 measurements of new product data of Fig. 1 versus 134.7 ksi√in for the comparison special processed 2024 T-3 point of Fig. 1), and even greater improvement (around 25%) over normal 2024. Fatigue cracks for the invention product at a cyclic stress intensity range of 22 ksi√in grew more than 44% slower (da/dN=5.3x10^{-5} in/cycle versus 9.52x10^{-5} in/cycle, $\frac{9.52 - 5.3}{9.52}$ = 44.33%!) as shown in the table below as compared to 2024 alloy even as processed according to the invention method to have better performance.

TABLE I

Fatigue Crack Propagation at Different Cyclic Stress Intensity Ranges

Sample	ΔK	da/dN
New Product	10	6.70×10^{-6}
	22	5.30×10^{-5}
	30	1.34×10^{-4}
Specially processed 2024-T3	10	7.91×10^{-6}
	22	9.52×10^{-5}
	30	3.71×10^{-4}

ΔK=Cyclic Stress Intensity Factor Range
da/dN=Length of crack growth during one load/unload cycle
Test performed with an R-ratio (min. load/max. load) equal to 0.33.

Fracture toughness was measured using a 16-inch wide, 44-inch long panel. All values given were taken in the T-L orientation which means that the applied load was parallel to the transverse direction of the sheet and the crack propagated parallel to the longitudinal direction of the sheet. Fatigue crack growth resistance was measured as the length a crack propagates during each cycle at a given stress intensity range. The measurements were made with an R-ratio of 0.33 in the T-L orientation. It is readily seen that as the stress intensity factor increases, the extent of the improvement becomes more prominent.

One possible explanation of part of the metallurgical causes of the improvement can be seen in Figures 3 and 4 which show differential scanning calorimetry curves. Differential scanning calometry offers a way to characterize the amount of coarse Al_2CuMg and Al_2Cu constituent particles. Because the

eutectic is comprised of these phases with aluminum melts between 500 and 580°C, the energy associated with the melting reaction is related to the volume fraction of the particles. Prior alloy 2024 products typically exhibit a value greater than 2.2 calories/gram for the energy of fusion associated with melting three phases. Sheet material of the invention generally has a 500 to 580°C differential scanning calorimetry peak of less than 1.0 cal/gram. Figures 3 and 4 show a comparison between the new product and 2024-T3 (which is the current material of choice for the fuselage skins of commercial jet aircraft) except that this particular 2024-T3 had been processed by special processing according to the invention which improved it over ordinary 2024.

Referring again to Figures 3 and 4 the size of the sharp peak that occurs in the temperature range of 500 to 530°C (Fig. 3) is indicative of the amount of constituent phase or phases such as Al_2CuMg and Al_2Cu present. These phases are believed to contribute to the lowering of a material's fracture toughness and its resistance to fatigue crack growth. The new product (Fig. 4) has a much smaller peak indicating that the volume fraction of such constituent has been significantly reduced in accordance with the present invention.

Sheet material of the invention is preferably characterized by a substantial absence or sparsity of secondary phase particles, e.g., Al_7Cu_2Fe, $Al_6(Fe, Mn)$ Al_2CuMg and Al_2Cu particles. That is, sheet material of the invention has generally not more than about 1.5 vol.%, preferably not more than 1.25 vol.%, of such particles larger than 0.15 square μm as

measured by optical image analysis through a cross section of the product.

The volume fraction of total large constituent phase particles (including Fe and Si bearing particles), e.g., larger than 0.15 square μm, was much smaller for the new product than for the conventionally treated 2024-T3. In twelve measurements, the new product volume fraction ranged from 0.756% to 1.056%. In twelve measurements, the specially treated 2024-T3 constituent volume fraction ranged from 1.429% to 2.185%.

Example 2

This example includes four parts.

In Part 1 (see Example 1, Part 1, the Example 1 processing being repeated for reading convenience), a 16-inch thick by 60-inch wide ingot in accordance with the invention containing 4.28% Cu, 1.38% Mg, 0.50% Mn, 0.07% Fe, 0.05% Si, balance Al, was cast. The metal was clad with alloy 1145 then preheated to approximately 875°F and hot rolled to a slab gauge of 4.5 inches. The slab was then reheated to a temperature above 910°F for 17 hours and hot rolled to a gauge of 0.176 inch. The metal was cold rolled to a final gauge of 0.1 inch and solution heat treated for 10 minutes at 925°F, quenched and stretched around 2% in length. Then the sheet was naturally aged for 3-weeks at room temperature. The strength, plane stress fracture toughness and resistance to fatigue crack growth of the product of this invention are listed in the table below.

In Part 2, a 16-inch thick comparision ingot having a composition in accordance with the invention and containing 4.26%

Cu, 1.37% Mg, 0.51% Mn, 0.08% Fe, 0.04% Si, balance Al, was cast. The metal was clad with alloy 1145 then it was given the same processing as described above for Part 1 except the 4.5 inch hot rolled slab was reheated to about 910° or 915°F for about 8 hours, but then held at 850°F for another 8 hours before the second hot rolling. In its final temper, this sheet had a lower combination of strength, toughness and resistance to fatigue crack growth than the product of this invention (see the table below). Specifically, the invention had a toughness 11.2% better than this comparison and this comparison's crack growth rate was 35% faster than that for the invention.

In Part 3 (see Example 1, Part 2, the processing being repeated for convenience in reading), a comparison ingot of 2024-T3, the alloy currently used for the fuselage skins of commercial jet airliners containing 4.54% Cu, 1.52% Mg, 0.64% Mn, 0.17% Fe, 0.08% Si, balance Al, was clad with alloy 1145 then was fabricated according to the process for the new product set forth above in Part 1 of this Example. This comparison material also had a lower combination of strength, toughness and resistance to fatigue crack growth than the product of this invention (see the table below). The invention had a 16% higher K_c toughness and the comparison material's crack growth rate was over 61% faster than the invention product's at ΔK=25 ksi√in ($\frac{9.08-5.62}{5.62}$ = 61.56%).

The table below also includes in Part 4 alloy 2024-T3 sheet clad with alloy 1145, the core 2024 containing 4.63% Cu, 1.58% Mg, 0.64% Mn, balance aluminum and impurities, using the

standard 2024-T3 processing. The fatigue crack growth resistance and toughness of this sheet represent the typical behavior of the existing product that is currently used for fuselage skins of commercial aircraft.

These four sets of data (Parts 1 to 4) on commercial size product made from commercial size ingot emphasize how the damage-tolerant property improvements (fracture toughness and fatigue crack growth rate) can be achieved using the composition and process described in this invention. Figure 5 illustrates strength versus toughness for Parts 1 to 4 of Example 2. Compared to 2024-T3, the product of this invention has over 33% higher T-L plane stress fracture K_c toughness and the 2024 fatigue crack growth rate at a ΔK of 25 was more than twice as fast as the invention product's. This shows the new product has clearly superior damage tolerant properties over the present 2024 T3 fuselage skin product. The data also show that, in order to achieve the optimum properties, it is important that both the composition and the process be in accordance with the invention.

TABLE II - EXAMPLE 2

Example 2	Sample	Long Transverse Yield Strength	T-L Plane Stress Fracture Toughness K_c	T-L da/dN *
Part 1	Invention Product	46.6	156.5	5.62×10^{-5}
Part 2	Invention Composition/ Low Temperature Hold Before Hot Roll	44.8	140.7	7.6×10^{-5}
Part 3	2024 Composition/ Invention Processing	46.4	134.7	9.08×10^{-5}
Part 4	2024-T3 Composition/ Low Temperature Reheat	43.8	117	11.6×10^{-5}

* Test performed with an R-ratio (minimum load/maximum load) equal to 0.1 and constant ΔK equal to 25 ksi$\sqrt{\text{in}}$; da/dN - Length of crack growth during one load/unload cycle. The test was a constant ΔK test, i.e., the loads (max and min) are reduced as the crack length grows.

Figure 6 shows typical strength versus toughness for the invention product in T3 temper and for commercial 2024-T3 for a number of commercial size lots for 0.1 inch thick sheet wherein it is clear that the invention product exhibits much better combinations of strength and T-L fracture toughness (K_C). In Figure 6 all the 2024 exhibits K_C toughness levels below 130 ksi√in (and most below 125 ksi√in) whereas all the invention product exhibits K_C above 130, above 135, above 140 and all equal to or exceed around 145 ksi√in. All but one of the invention products had a K_C level above 150 ksi√in and all had yield strength equal to or above 45 ksi, whereas a substantial amount of the 2024 T3 had yield strength below 45 ksi.

Figure 7 shows fatigue crack growth rate versus change in crack length for commercial size lots of the invention product in T3 temper versus commercial 2024-T3 for 0.1 inch thick sheet wherein it is clear that the fatigue crack growth rate for 2024 is much faster than (practically twice) the rate for the invention product.

The preferred maximum levels of fatigue crack growth rate for the invention product are shown in Figures 8 and 9 which delineate maximum crack growth rate levels for different ΔK and R values. Each figure includes a family of curves for different R values: R=0, 0.06, 0.1, 0.33 and 0.5 being shown. For R values between two of these values the maximum da/dN fatigue crack growth rate can be interpolated by estimation along a line between the closest R curves in accordance with known practices. For instance in Figure 8, at ΔK=25 and R=0.2, the maximum da/dN

in accordance with the invention is found by interpolation between the R=0.1 and R=0.33 curves to be about $1.5x10^{-4}$.

For Figure 8, the tests are the constant ΔK gradient test or the constant load test. For Figure 9, the test is the constant ΔK test at steady state. Figures 8a and 8b use curves (for R=0.1 and R=0.33) from Figure 8 as the heavy solid lines and add light line curves representing typical 2024 data. Again, the improvement of the invention is very noticeable in that the maximum fatigue crack growth rates shown for the invention are considerably below typical rates for 2024.

Figures 8 and 9 are intended to broadly encompass performance for preferred products in the respective tests for Figure 8 (constant ΔK gradient/constant load) and Figure 9 (constant ΔK test). This is intended to encompass any one or more of various test conditions as to ΔK or R (or both), for instance a constant ΔK (Fig. 9) of 30 ksi and R = 0.1. The invention product satisfies one or more of the test criteria shown in Figures 8 or 9 although in a broader sense than shown in Figures 8 and 9, the invention encompasses products having a maximum fatigue crack growth rate as shown in Figure 8 or 9 plus 5 or 10% or even 15%, especially at ΔK levels of 15 or 20, or preferably above 20 ksi√in., for instance 22 or 25 or 30 ksi√in. ΔK. Hence, reference to Figure 8 or 9 in the appended claims refers to any one (or more) set of test conditions embraced in said figures to set the maximum fatigue crack growth rate for that set of conditions or specifications.

Tables III and IV are intended as a further aid in reading Figures 8 and 9.

TABLE III

Maximum Fatigue Crack Propagation Rates, da/dN (in/cycle), of Invention Product at Selected Values of ΔK for the Constant K Gradient Test at Various R Ratios (Figure 8)

ΔK (ksi√in.)	da/dN at R=0	da/dN at R=0.06	da/dN at R=0.1	da/dN at R=0.33	da/dN at R=0.5
15	1.36×10^{-5}	1.59×10^{-5}	2.10×10^{-5}	2.68×10^{-5}	3.43×10^{-5}
20	3.38×10^{-5}	3.79×10^{-5}	5.26×10^{-5}	7.44×10^{-5}	1.18×10^{-4}
25	6.52×10^{-5}	7.44×10^{-5}	1.28×10^{-4}	1.93×10^{-4}	3.73×10^{-4}
30	1.37×10^{-4}	1.58×10^{-4}	3.06×10^{-4}	5.10×10^{-4}	1.16×10^{-3}

TABLE IV

Maximum Fatigue Crack Propagation Rates, da/dN (in/cycle), of Invention Product at Selected Values of ΔK for the Constant ΔK Gradient Test at Various R Ratios (Figure 9)

ΔK	da/dN at R=0.06	da/dN at R=0.1	da/dN at R=0.33	da/dN at R=0.5
15	1.26×10^{-5}	1.41×10^{-5}	1.93×10^{-5}	2.68×10^{-5}
20	2.68×10^{-5}	3.06×10^{-5}	4.18×10^{-5}	6.10×10^{-5}
25	5.00×10^{-5}	5.81×10^{-5}	7.81×10^{-5}	1.18×10^{-4}
30	8.48×10^{-5}	1.10×10^{-4}	1.37×10^{-4}	2.13×10^{-4}

One recent requirement for aircraft fuselage material is its fatigue crack growth rate (*da*/*dN*) in a constant ΔK test at a ΔK of 30 ksi√in and a stress ratio R of 0.1 wherein the crack growth rate after crack stabilization is measured. In one series of such tests, the invention product has exhibited a maximum crack growth rate of less than about 1.15×10^{-4} inches per cycle

at a test frequency of 2Hz and a relative humidity exceeding 95%. In these tests, a standard center slot test specimen with a center slot 0.2 inch long is fatigue cycled at a low load to cause the crack to grow. When the crack grows to 1/2 inch long, the load is increased so that $\Delta K = 30$ ksi√in. The test is continued at a constant ΔK of 30 ksi√in until the crack reaches a length of one inch. The steady state fatigue crack propagation (following an initial higher rate) was measured as the crack grew from about 0.6 or 0.7 inch to about one inch long. Accordingly, it will be appreciated that the invention product can satisfy a maximum of 1.8×10^{-4}, or 1.6×10^{-4}, or preferably 1.4×10^{-4}, or more preferably 1.2×10^{-4} inches per cycle in this type test. That is, a specification maximum from about 1.8×10^{-4} inch per cycle down to 1.2 or 1.15×10^{-4} inch per cycle in this test is equaled or bettered by the invention product. Thus in a substantially constant ΔK test wherein ΔK is substantially about 30 ksi√in (for instance 27 or 28 to 32 ksi√in or 30 ksi√in ± 10 or 15%) and R is substantially about 0.1 (for instance 0.1 ± 0.01 or 0.02) the maximum fatigue crack growth rate for invention sheet product includes the levels just described for the substantially steady state part of the test.

The fatigue crack growth rate testing herein described was performed in a relative humidity (R.H.) of 95%. This high R.H. makes the test more severe and more precise over tests run in uncontrolled ambient conditions. Figure 10 compares fatigue crack growth rate tests in 95% relative humidity versus ambient air for both the invention product and for 2024-T3 sheet. The

difference attributed to ambient versus high R.H. test conditions becomes significant at ΔK's below about 25 ksi√in with the difference increasing as ΔK decreases. For instance, at a ΔK of 20 ksi√in 2024-T3 *da/dN* is a little above 3×10^{-5} inch/cycle for an ambient air test, whereas it increases to about 5×10^{-5} for a 95% R.H. test. At a ΔK of 10 ksi√in, the *da/dN* figures for 2024-T3 are about 3×10^{-6} for ambient air and 6×10^{-6} for 95% R.H. test. At a ΔK of 7, the difference is even greater; about 8×10^{-7} in air versus 3.1×10^{-6} in 95% R.H. The table below further illustrates this difference.

TABLE V

Alloy	Test Condition	*da/dN* ΔK=7	ΔK=10	ΔK=20
2024-T3	Ambient	8×10^{-7}	3×10^{-6}	3×10^{-5}
	95% R.H.	3.1×10^{-6}	6×10^{-6}	5×10^{-5}
Improved Product	Ambient	6.5×10^{-7}	2×10^{-6}	1.8×10^{-5}
	95% R.H.	2.6×10^{-6}	4.5×10^{-6}	2.9×10^{-5}

Accordingly it can be preferable to conduct fatigue crack growth rate tests in an atmosphere having a relative humidity above 75 or 80%, preferably 85% or 90% minimum, more preferably around 95%, for instance 95% ± 5%.

Another factor that can influence fatigue crack growth rate test results is the frequency at which the loads are applied to the specimen in the test. This effect can be more pronounced

at higher relative humidity levels in the test environment. For instance, a difference in test frequency may be minimal or virtually non-existent if the test is carried out in dry argon. However, where the test is carried out in 95% relative humidity air, a lower test frequency generally produces higher fatigue crack growth rates. Unless indicated otherwise, for the tests conducted herein, the following frequencies were employed in the fatigue crack growth rate tests, the frequency referring to the number of times per second the test specimen was cycled from low to high load level and back. For constant ΔK tests, the frequency typically was approximately 5 Hz (5 cycles per second) for ΔK's other than 30 (about 2 Hz for $\Delta K = 30$ ksi$\sqrt{in}$), and for the constant ΔK gradient tests, the frequency started at approximately 25 cycles per second, but as the crack grew to a substantial length, the number of cycles per second decreased to frequencies of as low as 5 cycles per second because of equipment limitations. As is readily apparent, it can be useful to account for differences in test conditions in comparing one test to another, and it will be appreciated that in construing the extent of the present invention and the claims appended hereto, adjustments for different test conditions may be needed to appreciate the broad scope of the invention. Accordingly, in referring to Figures 8 and 9 in the claims as setting maximum da/dN levels, it is intended to adjust such for differences in test conditions such as humidity, cycles per unit time, or any other influence, as well as interpreting for R values different than those shown.

The extent of the invention's improvement over conventionally produced 2024-T3 commercial products in toughness (measured as K_c or as K_{app}) is at least 5 to 10%, ranging up to 20% or 30% or more. This enables guaranteeing a minimum level of toughness performance much higher than possible with conventional 2024, which normally was not specified to a minimum level of toughness, that is, toughness was not normally guaranteed for 2024.

The extent of the invention's improvement over conventionally produced 2024-T3 commercial products in reduced (lower) fatigue crack growth rate (a toughness related property) is pronounced, especially at medium to higher levels of ΔK such as 7 ksi√in to 15 ksi√in or, even more importantly, at ΔK levels above 15 ksi√in such as ΔK of 20 ksi√in to 25 ksi√in or 30 or more ksi√in ΔK where the extent of the improvement grows with increasing ΔK. The fatigue crack growth rate of the invention represents an improvement of at least 5 to 10 or 20% over 2024-T3 (crack grows at least 10 to 20% slower than for 2024-T3) and, especially at ΔK levels above 20, the invention represents an improvement of at least 10% and up to 50% or even more (at 50% improvement a crack grows half as fast as for 2024-T3).

In referring to improvements over 2024 or over 2024-T3, such generally and preferably refers to similar product form, for instance plate versus plate, clad sheet versus clad sheet, or at least to 2024 product forms expected to have similar property levels to the product form being compared.

The significance of the higher toughness and better (lower) fatigue crack growth rate achieved with the invention is that the aircraft fuselage designer can save significant weight by reducing the thickness of fuselage sheet or even by redesigning the structure to eliminate or reduce straps or other auxiliary, or secondary, components which are sometimes attached to fuselage skin to reinforce against tearing. Such auxiliary components, which can be generically referred to as "crack stoppers", decrease the stress in a cracked portion of the fuselage so that the crack shouldn't propagate beyond a certain point. The product of the invention has a fracture toughness so high, and fatigue crack growth rate so low, that it can facilitate designs without such components, or at least reduced components, for example, a reduced number of, or lighter weight, "tear crack stopper" components, or both, or even elimination of such components, without having to add excessive thickness to the fuselage skin itself to compensate for the reduced reinforcement. Another advantage of the lower rate of growth of cracks by fatigue achieved by the invention is that it allows the aircraft users to increase the intervals between inspection for cracks and defects, thereby reducing the costs of the inspections and reducing costs of operation and increasing the value of the aircraft to the user. The invention product also provides for increasing the number of pressurization/depressurizing or other stressful cycles further reducing operation costs and enhancing the value of an aircraft. In addition, the toughness of the improved products is so high that the aircraft designer's focus

for a material's robustness or damage tolerance can change from toughness measurements to fatigue crack growth rate.

Toughness and fatigue measuring and testing has been described in some particularity, it being understood that the aforesaid testing is intended to illustrate the good property levels of the invention but not necessarily in limitation thereof. For instance, other methods of testing may be developed over time and the good performance of the invention can be measured by those methods as well. It is to be understood that the invention product properties are generally or substantially equivalent to the described test results regardless of the particular test method used. It is to be understood that the herein described practices, especially preferred practices, impart to the invention alloy a condition where it exhibits good property combinations useful in aerospace and other uses.

The invention provides products suitable for use in large airplanes, such as large commercial passenger and freight airplanes, or other aircraft or aerospace vehicles. Such products, themselves, are typically large, typically several feet in length, for instance 5 or 10 feet up to 25 or 30 feet or even 50 feet or more, and 2 to 6 or 7 feet or more wide. Yet even in these large sizes, the invention products achieve good property combinations. Hence, a particular advantage of the invention is sufficiently large size products to be suited to major structure components in aircraft, such as major aircraft fuselage components and possibly other components such as wing section, fuselage section, tail section (empennage). The invention sheet

and plate product (generically referred to as rolled stock) can be shaped into a member for an airplane, such as a fuselage component or panel, or such as a wing component or panel, and the airplane can utilize the advantage of the invention as described. The shaping referred to can include bending, stretch forming, machining and other shaping operations known in the art. for shaping panels or other members for aircraft, aerospace or other vehicles. Forming involving bending or other plastic deformation can be performed at room temperature or at elevated temperatures such as around 200° to 400° or so. If elevated temperatures are used in forming, such can be used in an artificial aging treatment as earlier described. The member can also include attached stiffeners or strengtheners such as structural beams attached by riveting or other means.

Unless indicated otherwise, the following definitions apply herein:

a. The term "ksi" is equivalent to kilopounds per square inch.

b. Percentages for a composition refer to % by weight.

c. The term "ingot-derived" means solidified from liquid metal by a known or subsequently developed casting process rather than through powder metallurgy techniques. This term shall include, but not be limited to, direct chill casting, electromagnetic continuous casting, spray casting and any variations thereof.

d. In stating a numerical range for an element of a composition or a temperature or other process matter or a property or an extent of improvement or any other matter herein, and apart

The significance of the higher toughness and better (lower) fatigue crack growth rate achieved with the invention is that the aircraft fuselage designer can save significant weight by reducing the thickness of fuselage sheet or even by redesigning the structure to eliminate or reduce straps or other auxiliary, or secondary, components which are sometimes attached to fuselage skin to reinforce against tearing. Such auxiliary components, which can be generically referred to as "crack stoppers", decrease the stress in a cracked portion of the fuselage so that the crack shouldn't propagate beyond a certain point. The product of the invention has a fracture toughness so high, and fatigue crack growth rate so low, that it can facilitate designs without such components, or at least reduced components, for example, a reduced number of, or lighter weight, "tear crack stopper" components, or both, or even elimination of such components, without having to add excessive thickness to the fuselage skin itself to compensate for the reduced reinforcement. Another advantage of the lower rate of growth of cracks by fatigue achieved by the invention is that it allows the aircraft users to increase the intervals between inspection for cracks and defects, thereby reducing the costs of the inspections and reducing costs of operation and increasing the value of the aircraft to the user. The invention product also provides for increasing the number of pressurization/depressurizing or other stressful cycles further reducing operation costs and enhancing the value of an aircraft. In addition, the toughness of the improved products is so high that the aircraft designer's focus

for a material's robustness or damage tolerance can change from toughness measurements to fatigue crack growth rate.

Toughness and fatigue measuring and testing has been described in some particularity, it being understood that the aforesaid testing is intended to illustrate the good property levels of the invention but not necessarily in limitation thereof. For instance, other methods of testing may be developed over time and the good performance of the invention can be measured by those methods as well. It is to be understood that the invention product properties are generally or substantially equivalent to the described test results regardless of the particular test method used. It is to be understood that the herein described practices, especially preferred practices, impart to the invention alloy a condition where it exhibits good property combinations useful in aerospace and other uses.

The invention provides products suitable for use in large airplanes, such as large commercial passenger and freight airplanes, or other aircraft or aerospace vehicles. Such products, themselves, are typically large, typically several feet in length, for instance 5 or 10 feet up to 25 or 30 feet or even 50 feet or more, and 2 to 6 or 7 feet or more wide. Yet even in these large sizes, the invention products achieve good property combinations. Hence, a particular advantage of the invention is sufficiently large size products to be suited to major structure components in aircraft, such as major aircraft fuselage components and possibly other components such as wing section, fuselage section, tail section (empennage). The invention sheet

and plate product (generically referred to as rolled stock) can be shaped into a member for an airplane, such as a fuselage component or panel, or such as a wing component or panel, and the airplane can utilize the advantage of the invention as described. The shaping referred to can include bending, stretch forming, machining and other shaping operations known in the art. for shaping panels or other members for aircraft, aerospace or other vehicles. Forming involving bending or other plastic deformation can be performed at room temperature or at elevated temperatures such as around 200° to 400° or so. If elevated temperatures are used in forming, such can be used in an artificial aging treatment as earlier described. The member can also include attached stiffeners or strengtheners such as structural beams attached by riveting or other means.

Unless indicated otherwise, the following definitions apply herein:

a. The term "ksi" is equivalent to kilopounds per square inch.

b. Percentages for a composition refer to % by weight.

c. The term "ingot-derived" means solidified from liquid metal by a known or subsequently developed casting process rather than through powder metallurgy techniques. This term shall include, but not be limited to, direct chill casting, electromagnetic continuous casting, spray casting and any variations thereof.

d. In stating a numerical range for an element of a composition or a temperature or other process matter or a property or an extent of improvement or any other matter herein, and apart

from and in addition to the customary rules for rounding off numbers, such is intended to specifically designate and disclose each number, including each fraction and/or decimal, between the stated minimum and maximum for said range. (For example, a range of 1 to 10 discloses 1.1, 1.2...1.9, 2, 2.1, 2.2...and so on, up to 10. Similarly, a range of 500 to 1000 discloses 501, 502...and so on, up to 1000, including every number and fraction or decimal therewithin.) "Up to x" means "x" and every number less than "x", for instance up to 5 discloses 0.01...0.1...1 and so on up to 5.

While the invention is described in terms of certain specifics and embodiments, the claims herein are intended to encompass all equivalents and everything encompassed within the spirit of the invention.

Having thus described the invention, what is claimed is:

1. A method of producing an aluminum product comprising:

(a) providing stock comprising an aluminum alloy consisting essentially of, by weight, about 3.8 to 4.5% copper, about 1.2 to 1.8% magnesium, about 0.3 to 0.9% manganese, the remainder substantially aluminum, incidental elements and impurities;

(b) hot working said stock;

(c) heating said stock within about 900 to 950°F;

(d) hot rolling said stock;

(e) solution heat treating;

(f) cooling.

2. The method according to claim 1 wherein said alloy contains one or more elements from the group consisting of 0.02 to 0.4% Zr, 0.01 to 0.5% V, 0.01 to 0.4% Hf, 0.01 to 0.2% Cr, 0.01 to 1% Ag and 0.01 to 0.5% Sc, percentages being by weight.

3. The method according to claim 1 wherein said alloy contains a maximum of 0.25% Fe and a maximum of 0.25% Si, percentages being by weight.

4. The method according to claim 1 wherein said alloy contains a maximum of 0.15% Fe and a maximum of 0.15% Si, percentages being by weight.

5. The method according to claim 1 wherein said solution heat treating is within about 900° to 950°F.

6. The method according to claim 1 wherein said heating is within about 910° to 945°F.

7. The method according to claim 1 wherein said heating is within about 910° to 935°F.

8. The method according to claim 1 wherein said heating and solution heat treating are within about 910° to 945°F.

9. The method according to claim 1 wherein said heating and solution heat treating are within about 910° to 935°F.

10. The method according to claim 1 wherein said heating within about 900° to 950°F is longer than 2 hours.

11. The method according to claim 1 wherein said heating within about 900° to 950°F is 3 or more hours.

12. The method according to claim 1 wherein said heating within about 900° to 950°F is 4 to 24 hours.

13. The method according to claim 1 wherein, after said cooling, a working effect is imparted substantially equivalent to stretching at least 1% at room temperature.

14. The method according to claim 1 wherein, after said cooling, a working effect is imparted substantially equivalent to stretching at least 3% at room temperature.

15. The method according to claim 1 wherein, after said cooling, a working effect is imparted substantially equivalent to stretching at least 4% at room temperature.

16. The method according to claim 1 wherein, after said cooling and at least some significant aging effect, a working effect is imparted substantially equivalent to stretching at least 1% at room temperature.

17. The method according to claim 13 wherein said working effect includes stretching.

18. The method according to claim 13 wherein said working effect includes cold rolling.

19. The method according to claim 1 wherein said method includes, after said cooling, artificially aging above room temperature.

20. The method according to claim 1 wherein said method includes, after said cooling, artificially aging above room temperature, and during said artificial aging, forming or deforming the metal.

21. The method according to claim 1 wherein, subsequent to said cooling, a forming operation is performed above room temperature.

22. A method of producing an aluminum sheet product having good strength along with good fracture toughness or good resistance to fatigue crack growth, or both, said method comprising:

(a) providing stock comprising an aluminum alloy consisting essentially of, by weight, about 3.8 to 4.5% copper, about 1.2 to 1.8% magnesium, about 0.3 to 0.9% manganese, and containing about 0.01 to 0.2% iron, about 0.01 to 0.2% silicon, the remainder substantially aluminum, incidental elements and impurities;

(b) heating said stock within about 850° to 950°F;

(c) hot rolling said stock to a reduction in thickness of at least 40%;

(d) heating said hot rolled stock within about 900° to 950°F for more than 2 hours;

(e) further hot rolling said stock;

(f) cold rolling said stock to provide a cold rolled sheet;

(g) solution heat treating within about 900° to 950°F;

(h) cooling.

23. The method according to claim 22 wherein said heating in recitation (d) and said solution heat treating are within 905° to 945°F.

24. The method according to claim 22 wherein said alloy contains 0.15% max. Fe and 0.15% max. Si, percentages being by weight.

25. The method according to claim 22 wherein said alloy contains, by weight, 0.15% max. Fe and 0.15% max. Si and said heating in recitation (d) and said solution heat treating are within 905° to 945°F.

26. The method according to claim 22 wherein said heating in recitation (d) is for at least 3 hours.

27. The method according to claim 22 wherein said heating in recitation (d) is for at least 4 hours.

28. A method of producing an aluminum sheet product having good strength along with good fracture toughness or good resistance to fatigue crack growth, or both, said method comprising:

(a) providing stock comprising an aluminum alloy consisting essentially of, by weight, about 3.8 to 4.5% copper, about 1.2 to 1.8% magnesium, about 0.3 to 0.9% manganese, and containing about 0.01 to 0.2% iron, about 0.01 to 0.2% silicon, the remainder substantially aluminum, incidental elements and impurities;

(b) hot rolling said stock to a reduction in thickness of at least 40%;

(c) heating said hot rolled stock within about 900° to 950°F for more than 2 hours;

(d) further hot rolling said stock;

(e) solution heat treating within about 900° to 950°F;

(f) cooling.

29. The method according to claim 28 wherein said heating and solution heat treating are within 905° to 945°F.

30. The method according to claim 28 wherein said alloy contains, by weight, 0.15% max. Fe and 0.15% max. Si.

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31. The method according to claim 28 wherein said alloy contains, by weight, 0.15% max. Fe and 0.15% max. Si and said heating and solution heat treating are within 905° to 945°F.

32. The method according to claim 28 wherein said heating is for at least 3 hours.

33. The method according to claim 28 wherein said heating is for at least 4 hours.

34. A method of producing a clad aluminum product comprising:

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(a) providing stock comprising:

(i) an aluminum alloy consisting essentially of, by weight, about 3.8 to 4.5% copper, about 1.2 to 1.8% magnesium, about 0.3 to 0.9% manganese, the remainder substantially aluminum, incidental elements and impurities;

(ii) a cladding thereon of a different aluminum alloy or aluminum;

(b) hot working said stock;

(c) heating said stock within about 900° to 950°F;

(d) further hot rolling said stock;

(e) solution heat treating;

(f) cooling.

35. The method according to claim 34 wherein said alloy contains, by weight, 0.15% max. for Fe and 0.15% max. for Si.

36. The method according to claim 34 wherein said solution heat treating is within about 900° to 950°F.

37. The method according to claim 34 wherein both said heating and said solution heat treating are within about 910° to 945°F.

38. A method of producing a clad aluminum sheet product having good strength along with good fracture toughness or good resistance to fatigue crack growth, or both, said method comprising:

(a) providing stock comprising:

(i) an aluminum alloy consisting essentially of, by weight, about 3.8 to 4.5% copper, about 1.2 to 1.8% magnesium, about 0.3 to 0.9% manganese, about 0.2% max. iron, about 0.2% max. silicon, the remainder substantially aluminum, incidental elements and impurities;

(ii) a cladding thereon of a different aluminum alloy or aluminum;

(b) hot rolling said stock to a reduction in thickness of at least 40%;

(c) heating said stock within about 900° to 950°F for more than 2 hours;

(d) hot rolling said stock;

(e) cold rolling said stock;

(f) solution heat treating within about 900° to 950 °F;

(g) cooling.

39. The method according to claim 38 wherein said heating and solution heat treating are within 905° to 945°F.

40. The method according to claim 38 wherein said alloy contains, by weight, 0.15% max. Fe and 0.15% max. Si.

~~41. The method according to claim 38 wherein said alloy contains, by weight, 0.15% max. Fe and 0.15% max. Si and said heating and solution heat treating are within 905° to 945°F.~~

42. The method according to claim 38 wherein said heating is for at least 3 hours.

43. The method according to claim 38 wherein said heating is for at least 4 hours.

44. A method of producing a clad aluminum sheet product having good strength along with good fracture toughness or good resistance to fatigue crack growth, or both, said method comprising:

(a) providing stock comprising:

(i) an aluminum alloy consisting essentially of, by weight, about 3.8 to 4.5% copper, about 1.2 to 1.8% magnesium, about 0.3 to 0.9% manganese, and containing about 0.01 to 0.15% iron, about 0.01 to 0.15% silicon, the remainder substantially aluminum, incidental elements and impurities;

(ii) a cladding thereon of a different aluminum alloy or aluminum;

(b) hot rolling said stock to a reduction in thickness of at least 40%;

(c) heating said stock within about 900° to 950°F for more than 2 hours;

(d) hot rolling said stock;

(e) solution heat treating within about 900° to 950 °F;

(f) cooling.

45. The method according to claim 44 wherein said heating and solution heat treating are within 905° to 945°F.

46. The method according to claim 44 wherein said alloy contains, by weight, 1.2 to 1.6% Mg.

47. The method according to claim 44 wherein said alloy contains, by weight, 1.2 to 1.6% Mg and 4 to 4.5% Cu.

48. The method according to claim 44 wherein said heating is for at least 3 hours.

49. The method according to claim 44 wherein said heating is for at least 4 hours.

50. A method of producing a clad aluminum product having good strength along with good fracture toughness or good resistance to fatigue crack growth, or both, said method comprising:

(a) providing stock comprising:

(i) an aluminum alloy consisting essentially of, by weight, about 4 to 4.5% copper, about 1.2 to 1.5% magnesium, about 0.4 to 0.8% manganese, about 0.01 to 0.25% iron, about 0.01 to 0.25% silicon, the remainder substantially aluminum, incidental elements and impurities;

(ii) a cladding thereon of a different aluminum alloy or aluminum;

(b) hot rolling said stock;

(c) heating said stock to at least 900°F but not so high a temperature as to prevent achieving the aforesaid properties;

(d) further hot rolling said stock;

(e) solution heat treating;

(f) cooling.

51. A method of producing a clad aluminum sheet product having good strength along with good fracture toughness or good resistance to fatigue crack growth, or both, said method comprising:

(a) providing stock comprising:

(i) an aluminum alloy consisting essentially of, by weight, about 4 to 4.5% copper, about 1.2 to 1.5% magnesium, about 0.3 to 0.8% manganese, about 0.15% max. iron, about 0.15% max. silicon, the remainder substantially aluminum, incidental elements and impurities;

(ii) a cladding thereon of a different aluminum alloy or aluminum;

(b) hot rolling said stock to a reduction in thickness of at least 40%;

(c) heating said hot rolled stock within about 900° to 950°F for more than 2 hours;

(d) further hot rolling said stock;

(e) cold rolling said stock;

(f) solution heat treating within about 900° to 950 °F;

(g) cooling.

52. The method according to claim 51 wherein said alloy contains, by weight, not more than 0.12% Fe and not more than 0.1% Si.

53. The method according to claim 51 wherein said heating is for 3 or more hours.

54. The method according to claim 51 wherein said heating and said solution heat treating is within about 910° to 945°F.

55. The method according to claim 51 wherein said heating and said solution heat treating is within about 910° to 935°F.

56. A method of producing a clad aluminum sheet product having good strength along with good fracture toughness or good resistance to fatigue crack growth, or both, said method comprising:

(a) providing stock comprising:

(i) an aluminum alloy consisting essentially of, by weight, about 4 to 4.5% copper, about 1.2 to 1.5% magnesium, about 0.3 to 0.78% manganese, about 0.15% max. iron, about 0.15% max. silicon, the remainder substantially aluminum, incidental elements and impurities;

(ii) a cladding thereon of a different aluminum alloy or aluminum;

(b) hot rolling said stock to a reduction in thickness of at least 40%;

(c) heating said hot rolled stock within about 900° to 950°F for more than 2 hours;

(d) further hot rolling said stock;

(e) solution heat treating within about 900° to 950 °F;

(f) cooling.

57. The method according to claim 56 wherein said alloy contains, by weight, not more than 0.12% Fe and not more than 0.1% Si.

58. The method according to claim 56 wherein said heating is for 3 or more hours.

59. The method according to claim 56 wherein said heating and said solution heat treating is within about 910° to 945°F.

60. The method according to claim 56 wherein said heating and said solution heat treating is within about 910° to 935°F.

61. A method of producing a clad aluminum product having good strength along with good fracture toughness or good resistance to fatigue crack growth, or both, said method comprising:

(a) providing stock comprising:

(i) an aluminum alloy consisting essentially of, by weight, about 4 to 4.5% copper, about 1.2 to 1.5% magnesium, about 0.3 to 0.8% manganese, and containing about 0.01 to 0.15% iron, about 0.01 to 0.15% silicon, the remainder substantially aluminum, incidental elements and impurities;

(ii) a cladding thereon of a different aluminum alloy or aluminum;

(b) hot rolling said stock, comprising rolling within 600° to 900°F, to a reduction in thickness of at least 40%;

(c) heating said stock within about 910° to 935°F for about 3 to 24 hours;

(d) further hot rolling said stock comprising rolling within 550° to 900°F;

(e) solution heat treating at at least 900°F;

(f) cooling.

62. A method of producing a clad aluminum sheet product having good strength along with good fracture toughness or good resistance to fatigue crack growth, or both, said method comprising:

(a) providing stock comprising:

(i) an aluminum alloy consisting essentially of, by weight, about 4 to 4.5% copper, about 1.2 to 1.5% magnesium, about 0.3 to 0.8% manganese, and containing about 0.01 to 0.15% iron, about 0.01 to 0.15% silicon, the remainder substantially aluminum, incidental elements and impurities;

(ii) a cladding thereon of a different aluminum alloy or aluminum;

(b) hot rolling said stock, comprising rolling within 600° to 900°F, to a reduction in thickness of at least 40%;

(c) heating said stock within about 910° to 935°F for more than 2 hours;

(d) further hot rolling said stock comprising rolling within 550° to 900°F;

(e) cold rolling said stock to a thickness within 0.03 to about 0.3 inch sheet;

(f) solution heat treating at a temperature of at least 900°F;

(g) cooling.

63. A method of producing a clad aluminum product having good strength along with good fracture toughness or good resistance to fatigue crack growth, or both, said method comprising:

(a) providing aluminous stock comprising:

(i) an aluminum alloy consisting essentially of, by weight, about 3.9 to 4.5% copper, about 1.2 to 1.6% magnesium, about 0.3 to 0.8% manganese, and containing about 0.01 to 0.15% iron, about 0.01 to 0.15% silicon, the remainder substantially aluminum, incidental elements and impurities;

(ii) a cladding thereon of a different aluminum alloy or aluminum;

(b) hot rolling said stock;

(c) heating said hot rolled stock within 905° to 945°F;

(d) further hot rolling said stock;

(e) solution heat treating temperature within 900° to 945°F;

(f) cooling;

(g) imparting a cold work effect;

(h) natural aging.

64. A method of producing a clad aluminum product having good strength along with good fracture toughness or good resistance to fatigue crack growth, or both, said method comprising:

(a) providing aluminous stock comprising:

(i) an aluminum alloy consisting essentially of, by weight, about 3.9 to 4.5% copper, about 1.2 to 1.6% magnesium, about 0.3 to 0.8% manganese, and containing about 0.01 to 0.15% iron, about 0.01 to 0.15% silicon, the remainder substantially aluminum, incidental elements and impurities;

(ii) a cladding thereon of a different aluminum alloy or aluminum;

(b) hot rolling said stock;

(c) heating said hot rolled stock within 900° to 945°F for more than 2 hours;

(d) further hot rolling said stock;

(e) solution heat treating within 900° to 945°F;

(f) cooling;

(g) natural aging;

(h) imparting a cold work effect.

65. In a method wherein an aluminum alloy stock is shaped into an airplane member, the improvement wherein said stock is provided by a method comprising:

(a) providing aluminous stock comprising an aluminum alloy consisting essentially of, by weight, about 3.8 to 4.5% copper, about 1.2 to 1.8% magnesium, about 0.3 to 0.9% manganese, the remainder substantially aluminum, incidental elements and impurities;

(b) hot rolling said stock;

(c) heating said stock within about 900° to 950°F;

(d) further hot rolling said stock;

(e) solution heat treating;

(f) cooling.

66. In a method wherein an aluminum alloy stock is shaped into an airplane member, the improvement wherein said stock is provided by a method comprising:

(a) providing aluminous stock comprising:

(i) an aluminum alloy consisting essentially of, by weight, about 3.8 to 4.5% copper, about 1.2 to 1.8% magnesium, about 0.3 to 0.9% manganese, about 0.15% max. iron, about 0.15% max. silicon, the remainder substantially aluminum, incidental elements and impurities;

(ii) a cladding thereon of a different aluminum alloy or aluminum;

(b) hot rolling said stock;

(c) heating said stock within about 900° to 950°F;

(d) further hot rolling said stock;

(e) solution heat treating;

(f) cooling.

67. In a method wherein an aluminum alloy material is shaped into an airplane member, the improvement wherein said material is provided by a method comprising:

(a) providing aluminous stock comprising:

(i) an aluminum alloy consisting essentially of, by weight, about 4 to 4.5% copper, about 1.2 to 1.5% magnesium, about 0.4 to 0.8% manganese, and containing about 0.01 to 0.15% iron, about 0.01 to 0.15% silicon, the remainder substantially aluminum, incidental elements and impurities;

(ii) a cladding thereon of a different aluminum alloy or aluminum;

(b) hot rolling said stock, comprising rolling within 600° to 900°F, to a reduction in thickness of at least 40%;

(c) heating said hot rolled stock within 910° to 945°F for more than 2 hours;

(d) further hot rolling said stock comprising rolling within 550° to 900°F;

(e) solution heat treating within 900 to 945°F;

(f) cooling;

68. In a method wherein an aluminum alloy material is shaped into a vehicular panel, the improvement wherein said material is provided by a method comprising:

(a) providing aluminous stock comprising an aluminum alloy consisting essentially of, by weight, about 3.8 to 4.5% copper, about 1.2 to 1.8% magnesium, about 0.3 to 0.9% manganese, the remainder substantially aluminum, incidental elements and impurities;

(b) hot rolling said stock;

(c) heating said stock within 900° to 950°F;

(d) further hot rolling said stock;

(e) solution heat treating;

(f) cooling.

69. In a method wherein an aluminum alloy material is shaped into a vehicular panel, the improvement wherein said material is provided by a method comprising:

(a) providing aluminous stock comprising:

(i) an aluminum alloy consisting essentially of, by weight, about 3.8 to 4.5% copper, about 1.2 to 1.8% magnesium, about 0.3 to 0.9% manganese, the remainder substantially aluminum, incidental elements and impurities;

(ii) a cladding thereon of a different aluminum alloy or aluminum;

(b) hot rolling said stock;

(c) heating said stock within 900° to 945°F;

(d) further hot rolling said stock;

(e) solution heat treating;

(f) cooling.

70. A product comprising an aluminum base alloy consisting essentially of, by weight, about 3.8 to 4.5% copper, about 1.2 to 1.8% magnesium, about 0.3 to 0.9% manganese, the balance essentially aluminum and incidental elements and impurities, said product having a minimum long transverse yield strength of 40 ksi or more and at least 5% improvement over 2024 alloy in (a) T-L fracture toughness property, or (b) fatigue crack growth rate property at ΔK levels of 20 ksi√in or more, or in both said (a) and (b) properties.

71. An aluminum alloy sheet or plate product comprising an aluminum base alloy consisting essentially of, by weight, about 4 to 4.5% copper, about 1.2 to 1.5% magnesium, about 0.3 to 0.8% manganese, about 0.15% max. iron, about 0.15% max. silicon, the balance essentially aluminum and incidental elements and impurities, said product having a minimum long transverse yield strength of 40 ksi or more and at least 5% improvement over 2024 in (a) T-L fracture toughness property, or (b) fatigue crack growth rate property at ΔK levels of 20 ksi√in or more, or in both said (a) and (b) properties.

72. An aluminum alloy product comprising an aluminum base alloy consisting essentially of, by weight, about 3.8 to 4.5% copper, about 1.2 to 1.8% magnesium, about 0.3 to 0.9% manganese, the balance essentially aluminum and incidental elements and impurities, said aluminum alloy product having a minimum long transverse yield strength of 40 ksi or more, together with one or more of the following properties: (a) a maximum fatigue crack growth rate not greater than 10% above one or more of the levels shown in Figures 8 or 9; (b) a minimum T-L fracture toughness K_c of 140 ksi√in; (c) a minimum T-L fracture toughness K_{app} of 80 ksi√in.

73. An aluminum alloy sheet or plate product comprising an aluminum base alloy consisting essentially of, by weight, about 3.8 to 4.5% copper, about 1.2 to 1.8% magnesium, about 0.3 to 0.9% manganese, about 0.15% max. iron, about 0.15% max. silicon, the balance essentially aluminum and incidental elements and impurities, said aluminum alloy product having a minimum long transverse yield strength of 40 ksi or more together with one or more of the following properties: (a) a maximum fatigue crack growth rate not greater than 5% above one or more of the levels shown in Figures 8 or 9; (b) a minimum T-L fracture toughness at least equivalent to a K_c of 140 ksi√in in a test panel around 16 inches wide; (c) a minimum T-L fracture toughness at least equivalent to a K_{app} of 80 ksi√in in a test panel around 16 inches wide.

74. An aluminum alloy sheet product comprising an aluminum base alloy consisting essentially of, by weight, about 4 to 4.5% copper, about 1.2 to 1.5% magnesium, about 0.4 to 0.78% manganese, about 0.15% max. iron, about 0.15% max. silicon, the balance essentially aluminum and incidental elements and impurities, said sheet having a minimum long transverse yield strength of 40 ksi or more and a minimum T-L fracture toughness K_c of 140 ksi√in. or more and a fatigue crack growth rate not greater than 5% above one or more of the levels shown in Figures 8 or 9.

75. An aluminum alloy sheet product comprising an aluminum base alloy consisting essentially of, by weight, about 4 to 4.5% copper, about 1.2 to 1.5% magnesium, about 0.4 to 0.78% manganese, about 0.15% max. iron, about 0.15% max. silicon, the balance essentially aluminum and incidental elements and impurities, said sheet having a minimum long transverse yield strength of 40 ksi or more and a minimum T-L fracture toughness K_{app} of 80 ksi√in. or more and a fatigue crack growth rate not greater than 5% above one or more of the levels shown in Figures 8 or 9.

76. An aluminum alloy sheet or plate product comprising a first aluminum base alloy consisting essentially of, by weight, about 3.8 to 4.5% copper, about 1.2 to 1.8% magnesium, about 0.3 to 0.9% manganese, the balance essentially aluminum and incidental elements and impurities, and a cladding layer comprising aluminum or an aluminum alloy different from said first alloy on one or more faces thereof, said sheet having a minimum long transverse yield strength of 40 ksi or more and at least 5% improvement over 2024 in (a) T-L fracture toughness property, or (b) fatigue crack growth rate property at ΔK levels of 20 ksi√in or more, or in both said properties.

77. An aluminum alloy sheet or plate product comprising a first aluminum base alloy consisting essentially of, by weight, about 4 to 4.5% copper, about 1.2 to 1.5% magnesium, about 0.3 to 0.8% manganese, about 0.15% max. iron, about 0.15% max. silicon, the balance essentially aluminum and incidental elements and impurities, and a cladding layer comprising aluminum or an aluminum alloy different from said first alloy on one or more faces thereof, said sheet having a minimum long transverse yield strength of 40 ksi or more and at least 5% improvement over 2024 in (a) T-L fracture toughness property, or (b) fatigue crack growth rate property at ΔK levels of 20 ksi√in or more, or in both said properties.

78. An aluminum alloy sheet or plate product comprising a first aluminum base alloy consisting essentially of, by weight, about 4 to 4.5% copper, about 1.2 to 1.5% magnesium, about 0.4 to 0.7% manganese, the balance essentially aluminum and incidental elements and impurities, and a cladding layer comprising aluminum or an aluminum alloy different from said first alloy on one or more faces thereof, said sheet having a minimum long transverse yield strength of 40 ksi or more together with one or more of the following properties: (a) a maximum fatigue crack growth rate not greater than 10% above one or more of the levels shown in Figures 8 or 9; (b) a minimum T-L fracture toughness K_c of 140 ksi√in; (c) a minimum T-L fracture toughness K_{app} of 80 ksi√in.

79. An aluminum alloy sheet product comprising a first aluminum base alloy consisting essentially of, by weight, about 4 to 4.5% copper, about 1.2 to 1.5% magnesium, about 0.4 to 0.7% manganese, about 0.15% max. iron, about 0.15% max. silicon, the balance essentially aluminum and incidental elements and impurities, and a cladding layer on one or more faces thereof, said sheet having a minimum long transverse yield strength of 40 ksi or more and a minimum T-L fracture toughness K_c of 140 ksi√in. or more and a fatigue crack growth rate not greater than 5% above one or more of the levels shown in Figures 8 or 9.

80. An aluminum alloy sheet product having a core of an aluminum base alloy consisting essentially of, by weight, about 4 to 4.5% copper, about 1.2 to 1.5% magnesium, about 0.4 to 0.7% manganese, about 0.15% max. iron, about 0.15% max. silicon, the balance essentially aluminum and incidental elements and impurities, and a cladding layer on one or more faces thereof, said sheet having a minimum long transverse yield strength of 40 ksi or more and a minimum T-L fracture toughness K_{app} of 80 ksi√in. or more and a fatigue crack growth rate not greater than 5% above one or more of the levels shown in Figures 8 or 9.

81. An aluminum alloy sheet product comprising an aluminum base alloy consisting essentially of, by weight, about 3.8 to 4.5% copper, about 1.2 to 1.8% magnesium, about 0.3 to 0.9% manganese, about 0.15% max. iron, about 0.15% max. silicon, the balance essentially aluminum and incidental elements and impurities, said aluminum alloy product having a minimum long transverse yield strength of 40 ksi or more and exhibiting an average fatigue crack growth rate of not over $1.4X10^{-4}$ inch per cycle for growing a crack from about 1.7 inch to about 1 inch at a frequency of about 25 hertz and a stress ratio R of 0.1 and a substantially constant ΔK of about 30 ksi√in in an atmosphere of about 90% or more relative humidity.

82. An aluminum alloy sheet product comprising an aluminum base alloy consisting essentially of, by weight, about 3.8 to 4.5% copper, about 1.2 to 1.8% magnesium, about 0.3 to 0.9% manganese, about 0.15% max. iron, about 0.15% max. silicon, the balance essentially aluminum and incidental elements and impurities, and a cladding layer comprising aluminum or an aluminum alloy different from said core alloy on one or more faces thereof, said sheet having a minimum long transverse yield strength of 40 ksi or more and exhibiting an average fatigue crack growth rate of not over $1.4X10^{-4}$ inch per cycle for growing a crack from about 1.7 inch to about 1 inch at a frequency of about 25 hertz and a stress ratio R of 0.1 and a substantially constant ΔK of about 30 ksi√in in an atmosphere of about 90% or more relative humidity.

83. A vehicular panel comprising an aluminum alloy sheet product comprising an aluminum base alloy consisting essentially of, by weight, about 3.8 to 4.5% copper, about 1.2 to 1.8% magnesium, about 0.3 to 0.9% manganese, the balance essentially aluminum and incidental elements and impurities, said sheet having a minimum long transverse yield strength of 40 ksi or more and at least 5% improvement over 2024 in (a) T-L fracture toughness property, or (b) fatigue crack growth rate property at ΔK levels of 7 ksi√in or more, or in both said properties.

84. Aircraft skin comprising an aluminum alloy sheet product comprising an aluminum base alloy consisting essentially of, by weight, about 3.8 to 4.5% copper, about 1.2 to 1.8% magnesium, about 0.3 to 0.9% manganese, the balance essentially aluminum and incidental elements and impurities, said sheet having a minimum long transverse yield strength of 40 ksi or more and at least 5% improvement over 2024 in (a) T-L fracture toughness property, or (b) fatigue crack growth rate property at ΔK levels of 7 ksi√in or more, or in both said properties.

85. Aircraft skin comprising an aluminum alloy sheet product comprising an aluminum base alloy consisting essentially of, by weight, about 3.8 to 4.5% copper, about 1.2 to 1.8% magnesium, about 0.3 to 0.9% manganese, about 0.2% max. iron, about 0.2% max. silicon, the balance essentially aluminum and incidental elements and impurities, and a cladding layer comprising aluminum or an aluminum alloy different from said core alloy on one or more faces thereof, said sheet having a minimum long transverse yield strength of 40 ksi or more and at least 5% improvement over 2024 in (a) T-L fracture toughness property, or (b) fatigue crack growth rate property at ΔK levels of 7 ksi√in or more, or in both said properties.

86. Aircraft skin comprising an aluminum alloy product comprising an aluminum base alloy consisting essentially of, by weight, about 4 to 4.5% copper, about 1.2 to 1.5% magnesium, about 0.4 to 0.7% manganese, about 0.15% max. iron, about 0.15% max. silicon, the balance essentially aluminum and incidental elements and impurities, and a cladding layer comprising aluminum or an aluminum alloy different from said core alloy on one or more faces thereof, said sheet having a minimum long transverse yield strength of 40 ksi or more together with one or more of the following properties: (a) a maximum fatigue crack growth rate not greater than 10% above one or more of the levels shown in Figures 8 or 9; (b) a minimum T-L fracture toughness K_c of 140 ksi√in; (c) a minimum T-L fracture toughness K_{app} of 80 ksi√in.

87. Aircraft skin comprising an aluminum alloy product comprising an aluminum base alloy consisting essentially of, by weight, about 3.8 to 4.5% copper, about 1.2 to 1.8% magnesium, about 0.3 to 0.9% manganese, about 0.15% max. iron, about 0.15% max. silicon, the balance essentially aluminum and incidental elements and impurities, said aluminum alloy product having a minimum long transverse yield strength of 40 ksi or more together with one or more of the following properties: (a) a maximum fatigue crack growth rate not greater than one or more of the levels shown in Figures 8 or 9; (b) a minimum T-L fracture toughness K_c of 140 ksi√in; (c) a minimum T-L fracture toughness K_{app} of 80 ksi√in.

88. Aircraft fuselage skin comprising an aluminum alloy sheet product comprising an aluminum base alloy consisting essentially of, by weight, about 3.8 to 4.5% copper, about 1.2 to 1.8% magnesium, about 0.3 to 0.9% manganese, the balance essentially aluminum and incidental elements and impurities, said sheet having a minimum long transverse yield strength of 40 ksi or more and at least 5% improvement over 2024 in (a) T-L fracture toughness property, or (b) fatigue crack growth rate property at ΔK levels of 7 ksi√in or more, or in both said properties.

89. Aircraft fuselage skin comprising an aluminum alloy product comprising an aluminum base alloy consisting essentially of, by weight, about 3.8 to 4.5% copper, about 1.2 to 1.8% magnesium, about 0.3 to 0.9% manganese, the balance essentially aluminum and incidental elements and impurities, said aluminum alloy product having a minimum long transverse yield strength of 40 ksi or more together with one or more of the following properties: (a) a maximum fatigue crack growth rate not greater than 5% above one or more of the levels shown in Figures 8 or 9; (b) a minimum T-L fracture toughness K_c of 140 ksi√in; (c) a minimum T-L fracture toughness K_{app} of 80 ksi√in.

90. Aircraft fuselage skin comprising an aluminum alloy sheet product comprising an aluminum base alloy consisting essentially of, by weight, about 3.8 to 4.5% copper, about 1.2 to 1.8% magnesium, about 0.3 to 0.9% manganese, the balance essentially aluminum and incidental elements and impurities, and a cladding layer comprising aluminum or an aluminum alloy different from said core alloy on one or more faces thereof, said sheet having a minimum long transverse yield strength of 40 ksi or more and at least 5% improvement over 2024 in (a) T-L fracture toughness property, or (b) fatigue crack growth rate property at ΔK levels of 7 ksi√in or more, or in both said properties.

91. Aircraft fuselage skin comprising an aluminum alloy product comprising an aluminum base alloy consisting essentially of, by weight, about 4 to 4.5% copper, about 1.2 to 1.5% magnesium, about 0.4 to 0.8% manganese, the balance essentially aluminum and incidental elements and impurities, and a cladding layer comprising aluminum or an aluminum alloy different from said core alloy on one or more faces thereof, said sheet having a minimum long transverse yield strength of 40 ksi or more together with one or more of the following properties: (a) a maximum fatigue crack growth rate not greater than one or more of the levels shown in Figures 8 or 9; (b) a minimum T-L fracture toughness K_c of 150 ksi√in; (c) a minimum T-L fracture toughness K_{app} of 90 ksi√in.

Rul 98

92. An aircraft fuselage, or fuselage portion, having reduced tear retarding auxiliary components, said fuselage or portion comprising fuselage skin comprising an aluminum alloy sheet product comprising an aluminum base alloy consisting essentially of, by weight, about 3.8 to 4.5% copper, about 1.2 to 1.8% magnesium, about 0.3 to 0.9% manganese, the balance essentially aluminum and incidental elements and impurities, said sheet having a minimum long transverse yield strength of 40 ksi or more and at least 5% improvement over 2024 in (a) T-L fracture toughness property, or (b) fatigue crack growth rate property at ΔK levels of 7 ksi√in or more, or in both said properties.

93. An aircraft fuselage, or fuselage portion, having reduced tear retarding auxiliary components, said fuselage or portion comprising an aluminum alloy sheet product comprising an aluminum base alloy consisting essentially of, by weight, about 3.8 to 4.5% copper, about 1.2 to 1.8% magnesium, about 0.3 to 0.9% manganese, the balance essentially aluminum and incidental elements and impurities, said aluminum alloy product having a minimum long transverse yield strength of 40 ksi or more together with one or more of the following properties: (a) a maximum fatigue crack growth rate not greater than 5% above one or more of the levels shown in Figures 8 or 9; (b) a minimum T-L fracture toughness K_c of 150 ksi√in; (c) a minimum T-L fracture toughness K_{app} of 90 ksi√in.

94. An aircraft fuselage, or fuselage portion, having reduced tear retarding auxiliary components, said fuselage or portion comprising fuselage skin comprising an aluminum alloy sheet product comprising an aluminum base alloy consisting essentially of, by weight, about 3.8 to 4.5% copper, about 1.2 to 1.8% magnesium, about 0.3 to 0.9% manganese, the balance essentially aluminum and incidental elements and impurities, and a cladding layer comprising aluminum or an aluminum alloy different from said core alloy on one or more faces thereof, said sheet having a minimum long transverse yield strength of 40 ksi or more and at least 5% improvement over 2024 in (a) T-L fracture toughness property, or (b) fatigue crack growth rate property at ΔK levels of 7 ksi√in or more, or in both said properties.

95. An aircraft fuselage, or fuselage portion, having reduced tear retarding auxiliary components, said fuselage or portion comprising fuselage skin comprising an aluminum alloy product comprising an aluminum base alloy consisting essentially of, by weight, about 4 to 4.5% copper, about 1.2 to 1.5% magnesium, about 0.3 to 0.8% manganese, about 0.15% max. iron, about 0.15% max. silicon, the balance essentially aluminum and incidental elements and impurities, and a cladding layer comprising aluminum or an aluminum alloy different from said core alloy on one or more faces thereof, said sheet having a minimum long transverse yield strength of 40 ksi or more together with one or more of the following properties: (a) a maximum fatigue crack growth rate not greater than one or more of the levels shown in Figures 8 or 9; (b) a minimum T-L fracture toughness K_c of 150 ksi√in; (c) a minimum T-L fracture toughness K_{app} of 90 ksi√in.

96. An aircraft having skin material comprising an aluminum alloy sheet product comprising an aluminum base alloy consisting essentially of, by weight, about 3.8 to 4.5% copper, about 1.2 to 1.8% magnesium, about 0.3 to 0.9% manganese, and containing about 0.01 to 0.15% iron, about 0.01 to 0.15% silicon, the balance essentially aluminum and incidental elements and impurities, said sheet having a minimum long transverse yield strength of 40 ksi or more and at least 5% improvement over 2024 in (a) T-L fracture toughness property, or (b) fatigue crack growth rate property at ΔK levels of 10 ksi√in or more, or in both said properties.

97. An aircraft having skin material comprising an aluminum alloy product comprising an aluminum base alloy consisting essentially of, by weight, about 3.8 to 4.5% copper, about 1.2 to 1.8% magnesium, about 0.3 to 0.9% manganese, about 0.2% max. iron, about 0.2% max. silicon, the balance essentially aluminum and incidental elements and impurities, said aluminum alloy product having a minimum long transverse yield strength of 40 ksi or more together with one or more of the following properties: (a) a maximum fatigue crack growth rate not greater than 5% above one or more of the levels shown in Figures 8 or 9; (b) a minimum T-L fracture toughness K_c of 150 ksi√in; (c) a minimum T-L fracture toughness K_{app} of 90 ksi√in.

Pull 98

98. An aircraft having skin material comprising an aluminum alloy sheet product comprising an aluminum base alloy consisting essentially of, by weight, about 3.8 to 4.5% copper, about 1.2 to 1.8% magnesium, about 0.3 to 0.9% manganese, about 0.2% max. iron, about 0.2% max. silicon, the balance essentially aluminum and incidental elements and impurities, and a cladding layer comprising aluminum or an aluminum alloy different from said core alloy on one or more faces thereof, said sheet having a minimum long transverse yield strength of 40 ksi or more and at least 5% improvement over 2024 in (a) T-L fracture toughness property, or (b) fatigue crack growth rate property at ΔK levels of 10 ksi√in or more, or in both said properties.

99. An aircraft having skin material comprising an aluminum alloy product comprising an aluminum base alloy consisting essentially of, by weight, about 4 to 4.5% copper, about 1.2 to 1.5% magnesium, about 0.4 to 0.7% manganese, about 0.15% max. iron, about 0.12% max. silicon, the balance essentially aluminum and incidental elements and impurities, and a cladding layer comprising aluminum or an aluminum alloy different from said core alloy on one or more faces thereof, said sheet having a minimum long transverse yield strength of 40 ksi or more together with one or more of the following properties: (a) a maximum fatigue crack growth rate not greater than 5% above one or more of the levels shown in Figures 8 or 9; (b) a minimum T-L fracture toughness K_c of 140 ksi√in; (c) a minimum T-L fracture toughness K_{app} of 80 ksi√in.

100. An aircraft having a fuselage skin, said fuselage skin comprising an aluminum alloy sheet product comprising an aluminum base alloy consisting essentially of, by weight, about 3.8 to 4.5% copper, about 1.2 to 1.8% magnesium, about 0.3 to 0.9% manganese, the balance essentially aluminum and incidental elements and impurities, said sheet having a minimum long transverse yield strength of 40 ksi or more and at least 5% improvement over 2024 in (a) T-L fracture toughness property, or (b) fatigue crack growth rate property at ΔK levels of 7 ksi√in or more, or in both said properties.

101. An aircraft having a fuselage skin, said fuselage skin comprising an aluminum alloy product comprising an aluminum base alloy consisting essentially of, by weight, about 3.8 to 4.5% copper, about 1.2 to 1.8% magnesium, about 0.3 to 0.9% manganese, about 0.15% max. iron, about 0.15% max. silicon, the balance essentially aluminum and incidental elements and impurities, said aluminum alloy product having a minimum long transverse yield strength of 40 ksi or more together with one or more of the following properties: (a) a maximum fatigue crack growth rate not greater than 5% above one or more of the levels shown in Figures 8 or 9; (b) a minimum T-L fracture toughness K_C of 140 ksi√in; (c) a minimum T-L fracture toughness K_{app} of 80 ksi√in.

102. An aircraft having a fuselage skin, said fuselage skin comprising an aluminum alloy sheet product comprising an aluminum base alloy consisting essentially of, by weight, about 3.8 to 4.5% copper, about 1.2 to 1.8% magnesium, about 0.3 to 0.9% manganese, the balance essentially aluminum and incidental elements and impurities, and a cladding layer comprising aluminum or an aluminum alloy different from said core alloy on one or more faces thereof, said sheet having a minimum long transverse yield strength of 40 ksi or more and at least 5% improvement over 2024 in (a) T-L fracture toughness property, or (b) fatigue crack growth rate property at ΔK levels of 7 ksi√in or more, or in both said properties.

103. An aircraft having a fuselage skin, said fuselage skin comprising an aluminum alloy product comprising an aluminum base alloy consisting essentially of, by weight, about 4 to 4.5% copper, about 1.2 to 1.5% magnesium, about 0.4 to 0.7% manganese, about 0.15% max. iron, about 0.15% max. silicon, the balance essentially aluminum and incidental elements and impurities, and a cladding layer comprising aluminum or an aluminum alloy different from said core alloy on one or more faces thereof, said sheet having a minimum long transverse yield strength of 40 ksi or more together with one or more of the following properties: (a) a maximum fatigue crack growth rate not greater than 5% above one or more of the levels shown in Figures 8 or 9; (b) a minimum T-L fracture toughness K_c of 140 ksi√in; (c) a minimum T-L fracture toughness K_{app} of 80 ksi√in.

104. A method according to claim 64 wherein said recitation (h) comprises stretching.

105. A method according to claim 63 wherein said recitation (g) comprises stretching.

106. A method according to claim 64 wherein said recitation (h) comprises cold rolling.

107. A method according to claim 63 wherein said recitation (g) comprises cold rolling.

108. A method according to claim 64 wherein solution heat treating is preceded by cold rolling.

109. A method according to claim 63 wherein solution heat treating is preceded by cold rolling.

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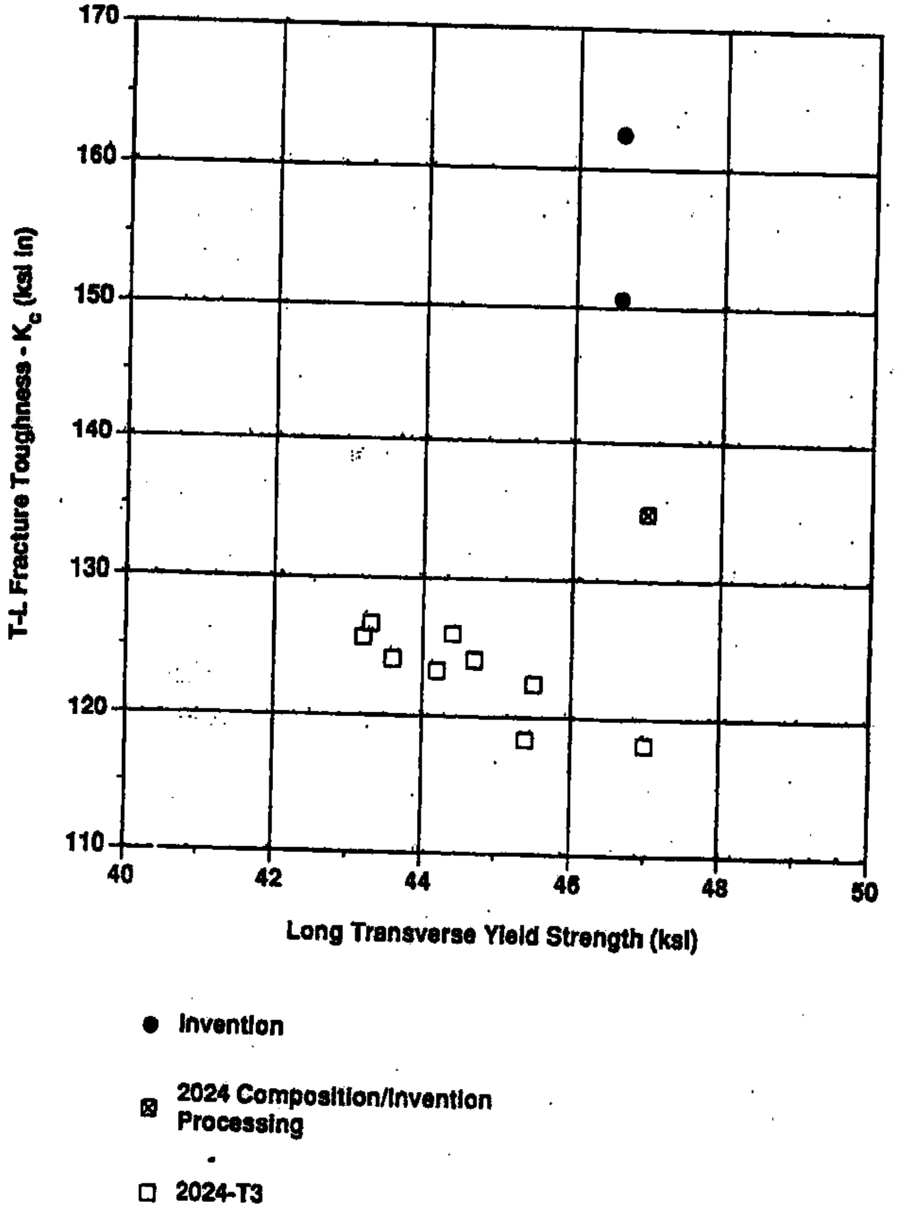

Figure 1

As Originally Filed

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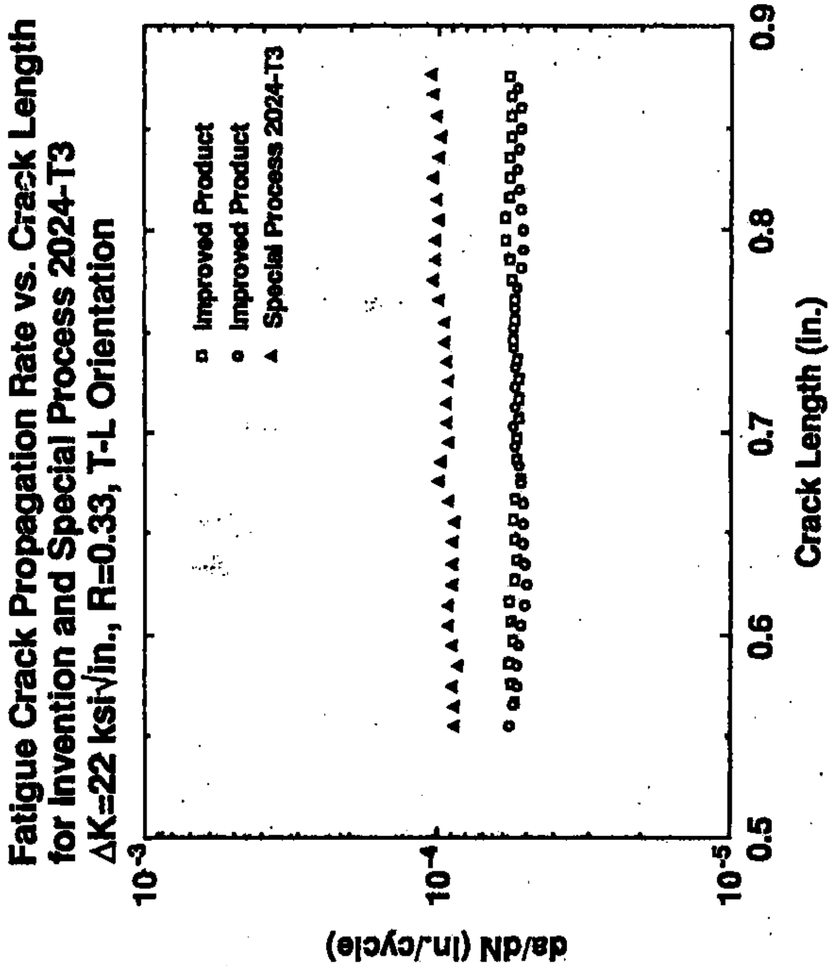

Figure 2

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Invention to 2024-T3 Fatigue Crack Propagation Rate Ratio versus ΔK Applied

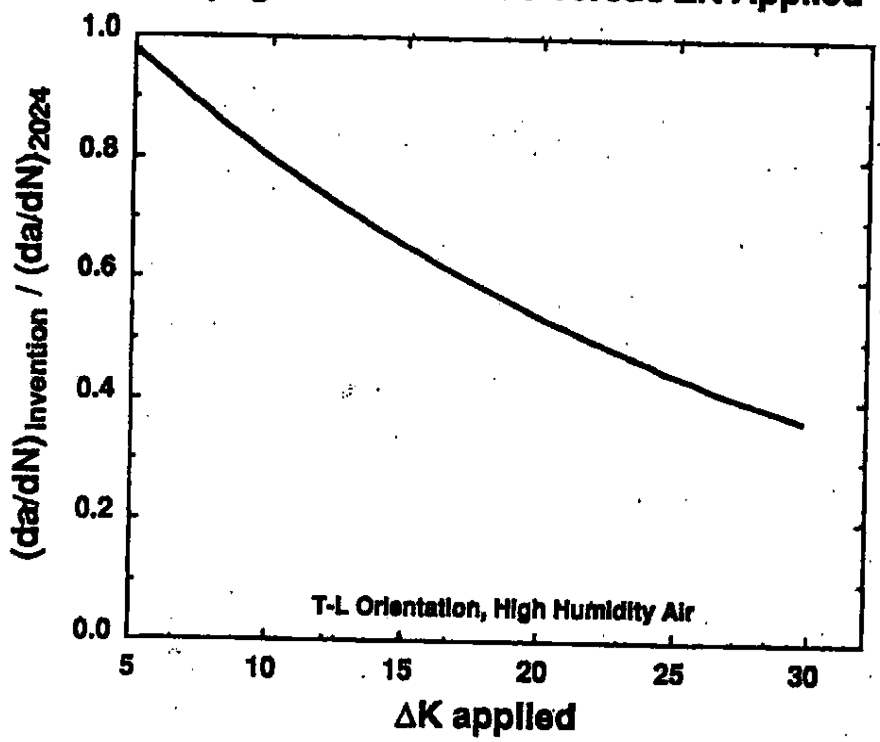

Figure 2a

As Originally Filed

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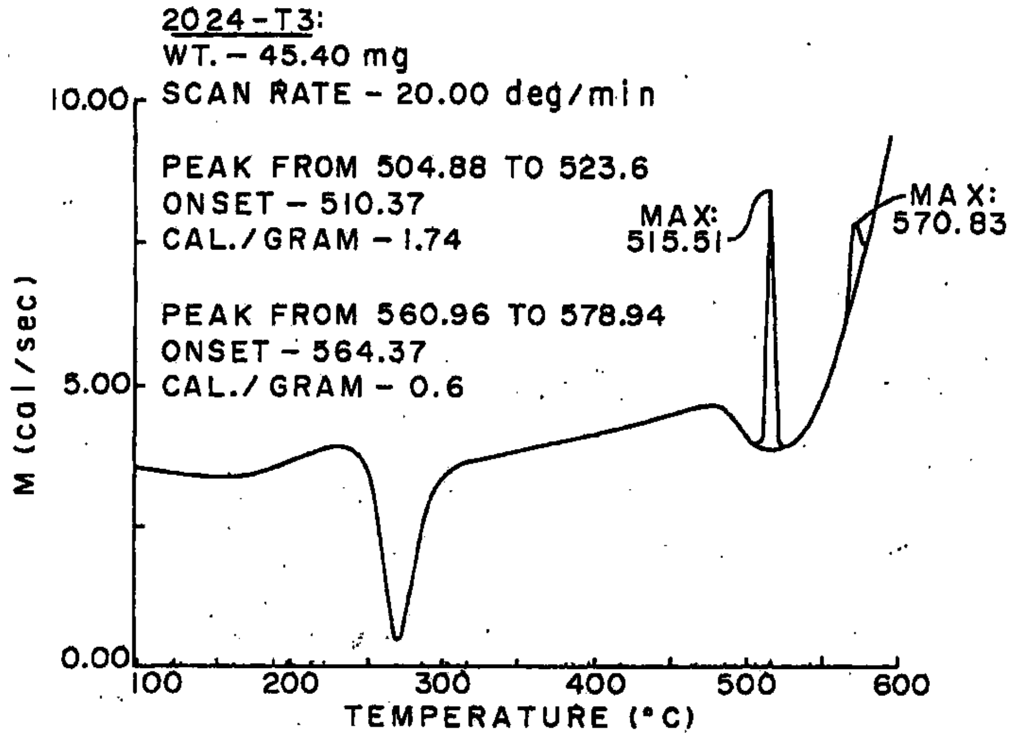

FIG. 3

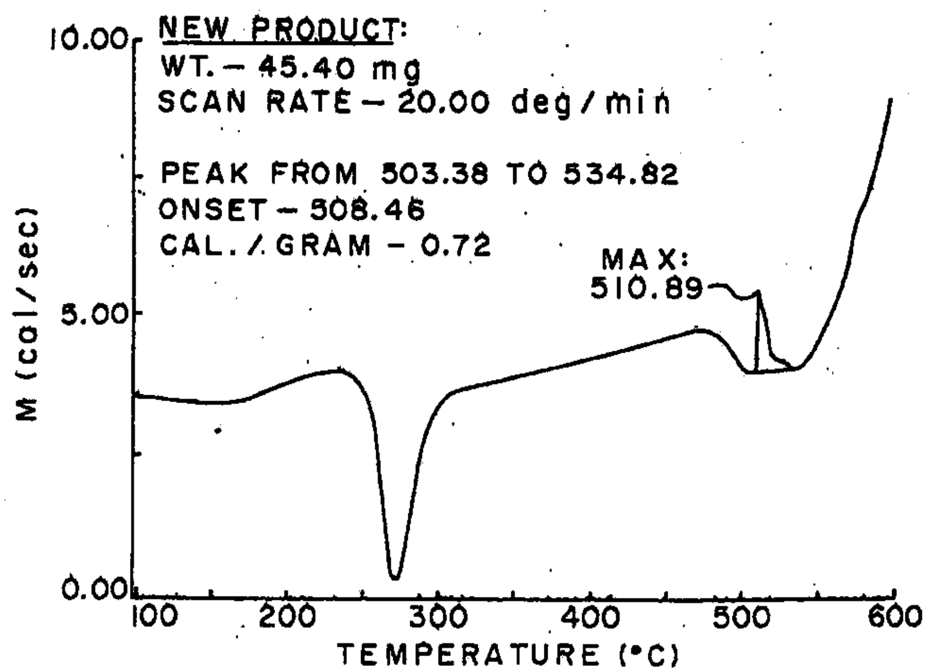

FIG. 4

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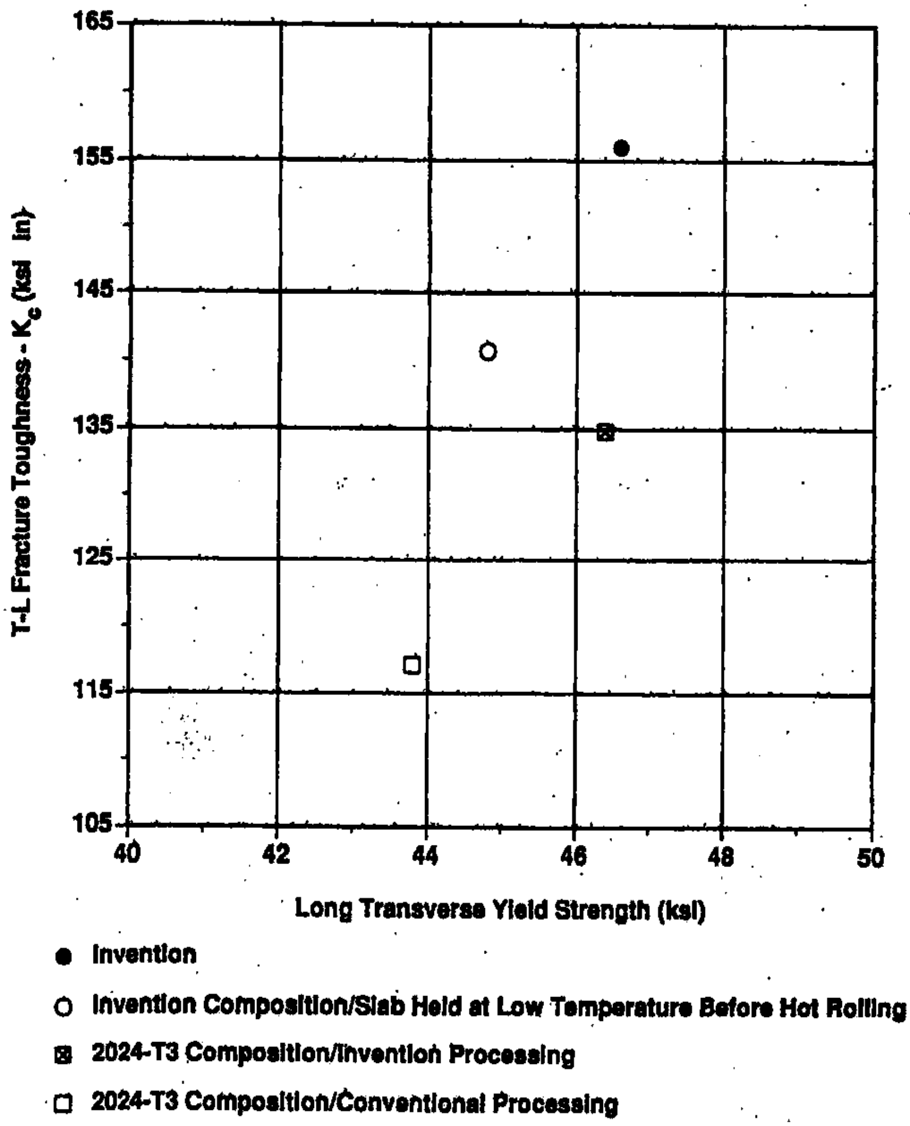

Figure 5.

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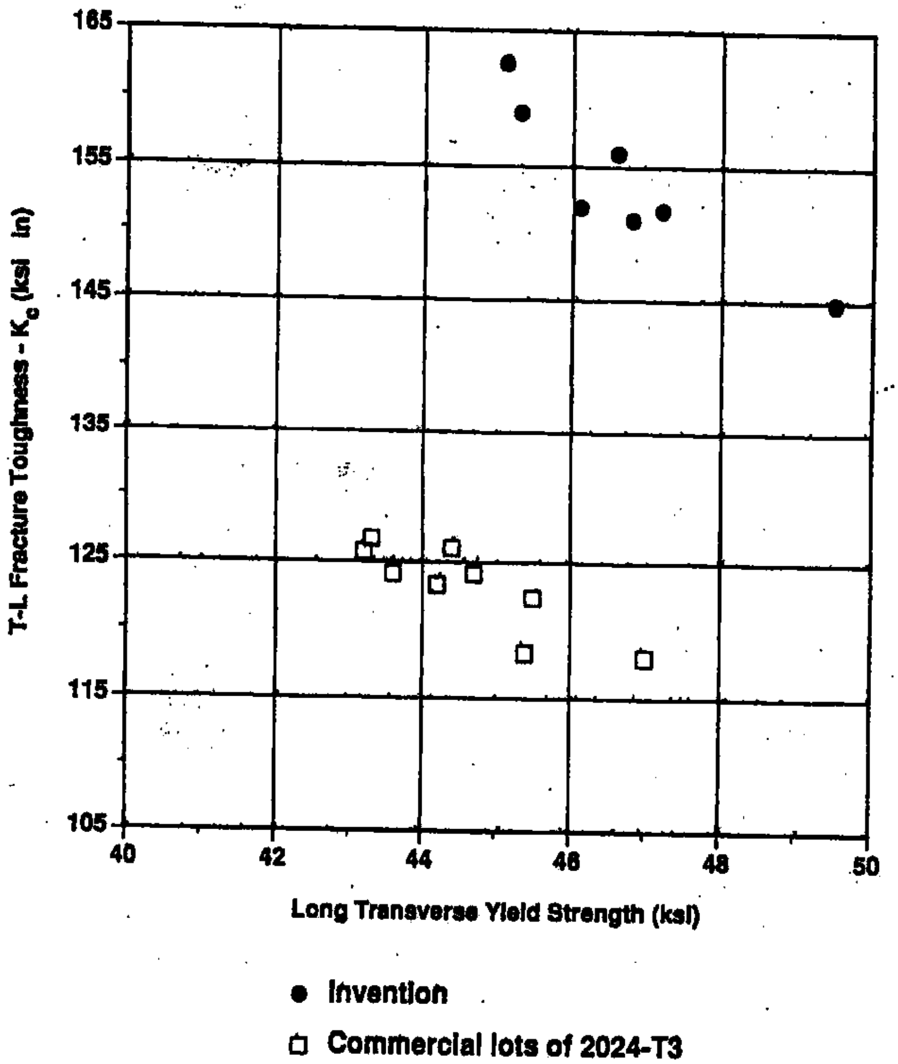

Figure 6

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Fatigue Crack Propagation Rate versus Change in Crack Length, $\Delta K=30$ ksi$\sqrt{in.}$, R=0.1, High Humidity Air

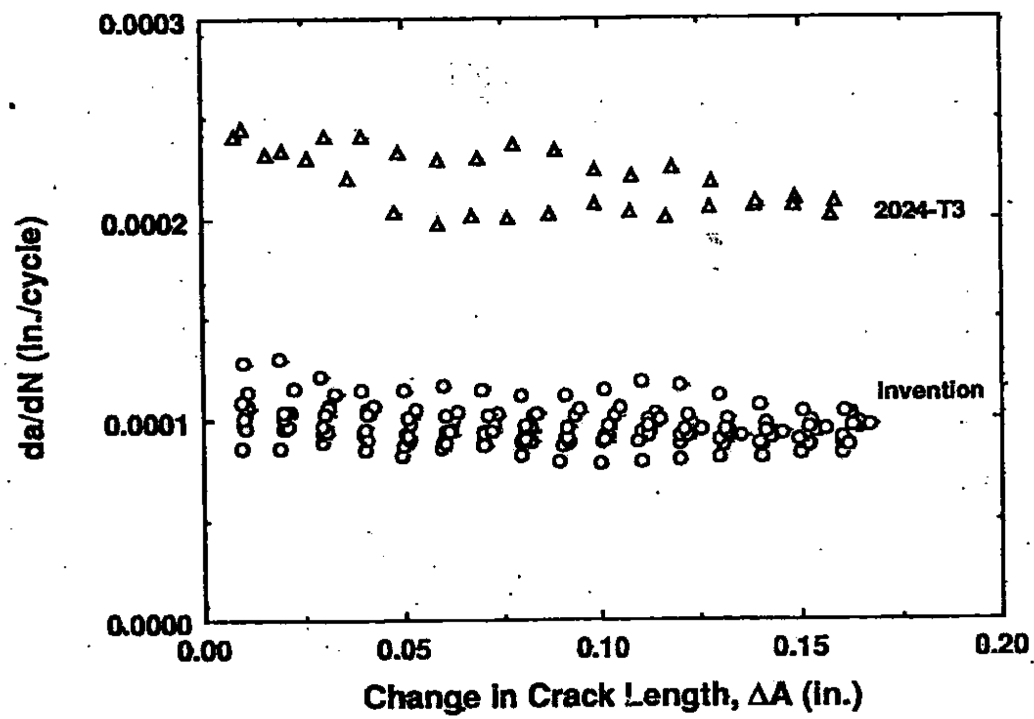

Figure 7

Maximum Fatigue Crack Propagation Rates versus Applied ΔK for Various R-Ratios

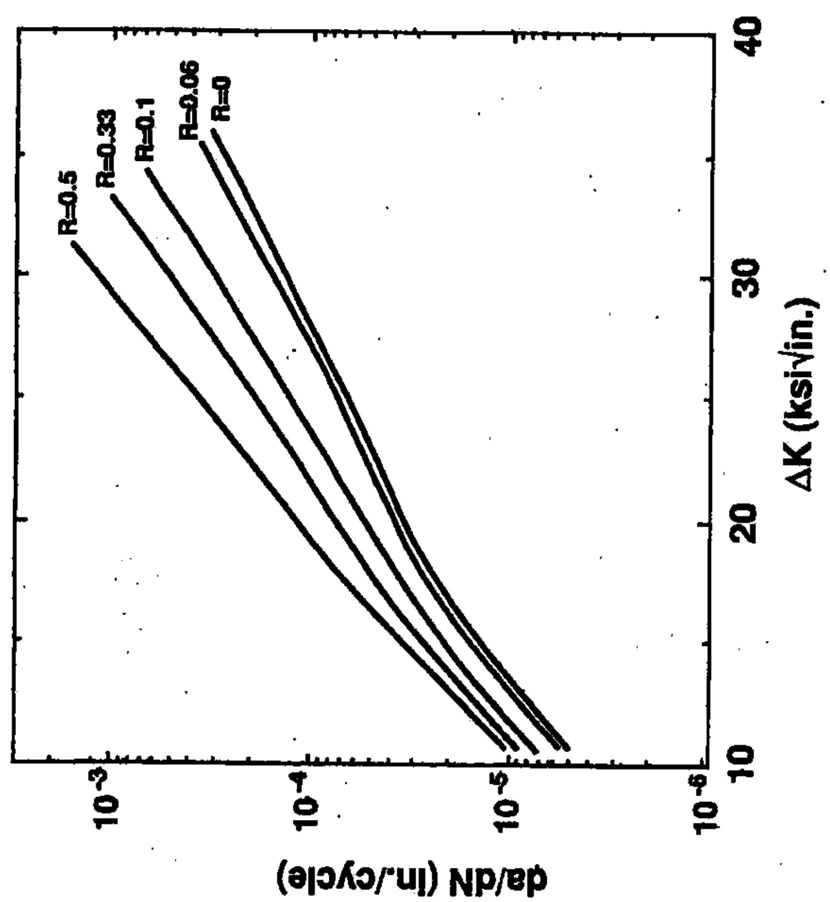

Figure 8

Print Of Drawings As Originally Filed

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Maximum Fatigue Crack Propagation Rates versus Applied ΔK for R = 0.33

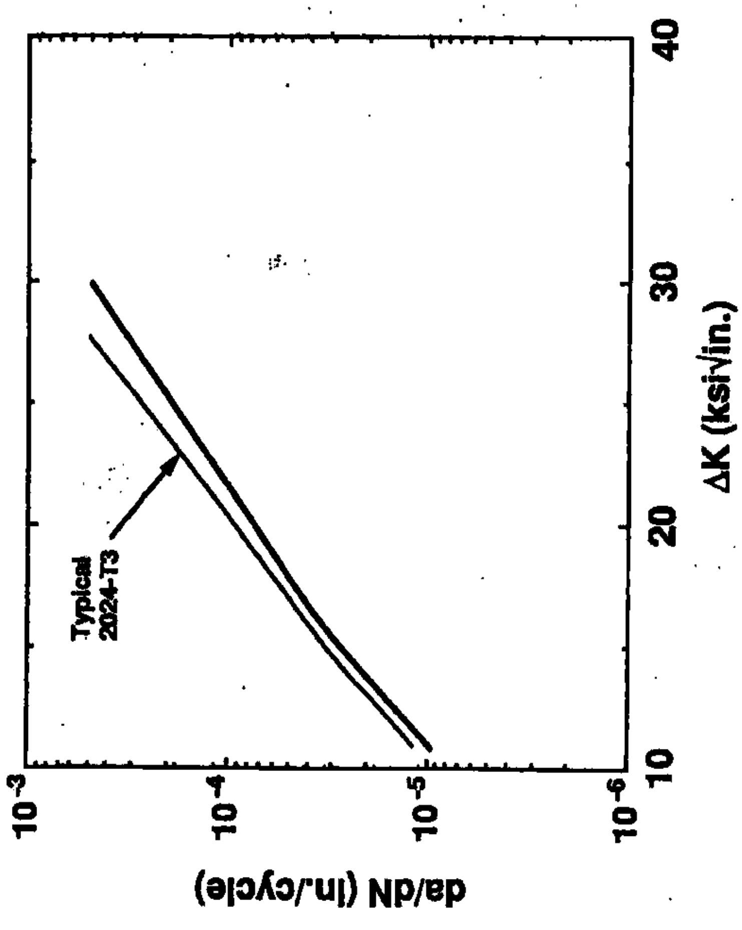

Figure 8a

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Maximum Fatigue Crack Propagation Rates versus Applied ΔK for R = 0.1

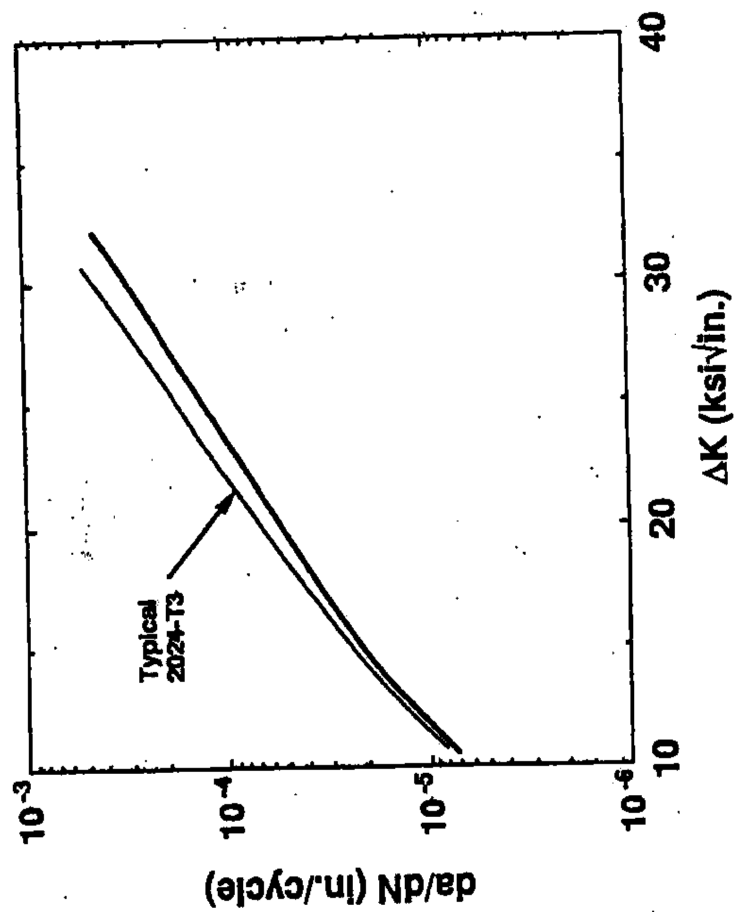

Figure 8b

Print Of Drawings
As Originally Filed

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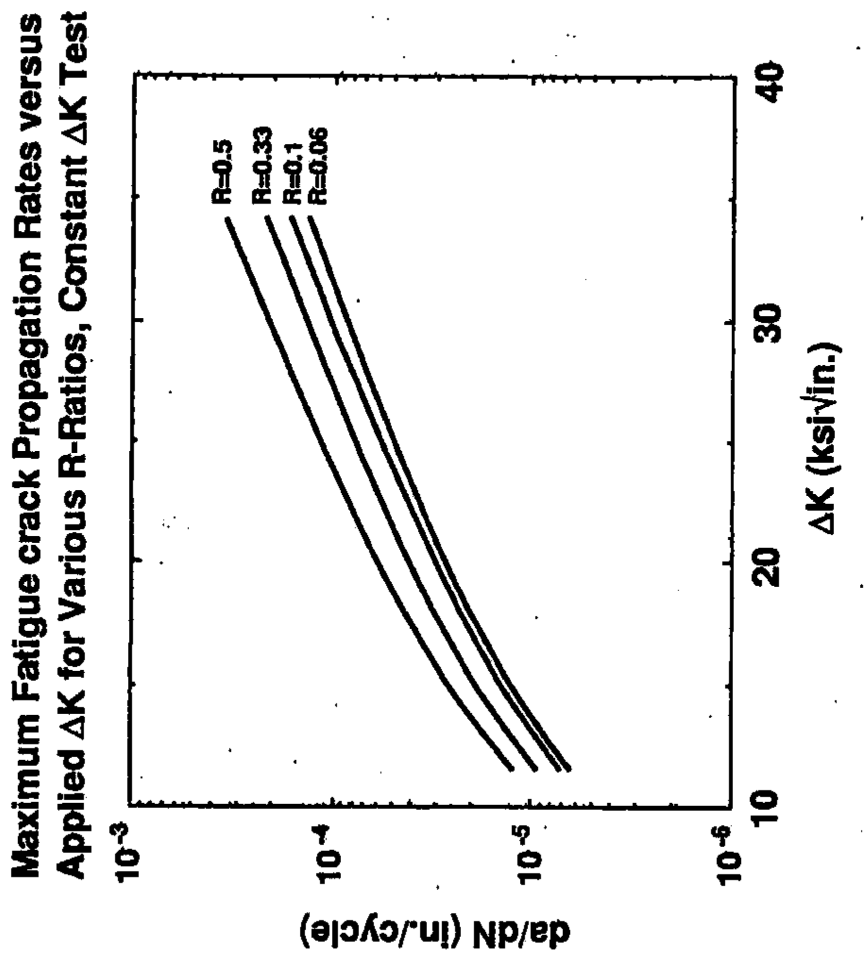

Figure 9

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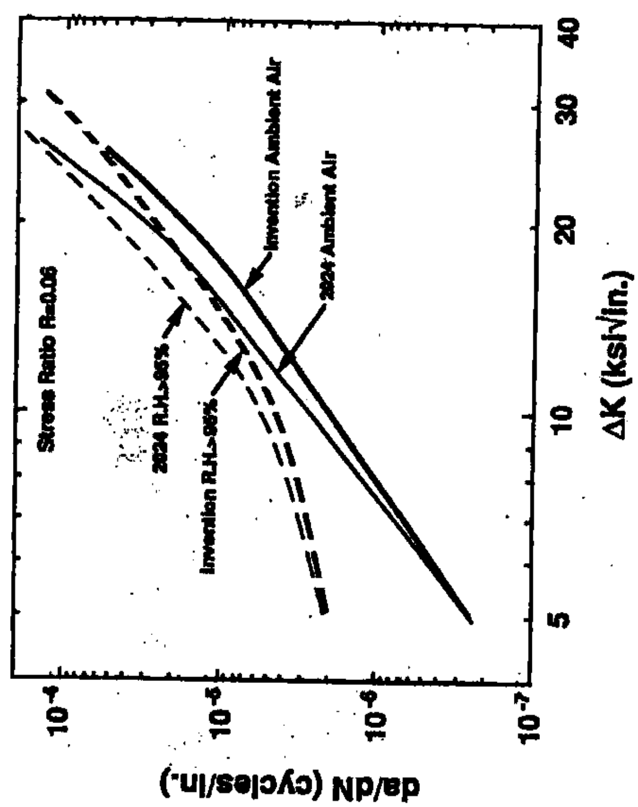

Effect of Humidity on Fatigue Crack Growth Rates of Invention and 2024-T3 Sheet

Figure 10

Exhibit 10

REGISTRATION RECORD SERIES
TEAL SHEETS

International Alloy Designations and Chemical Composition Limits for Wrought Aluminum and Wrought Aluminum Alloys

The Aluminum Association
Incorporated
1525 Wilson Boulevard, Arlington, VA 22209
www.aluminum.org

With Support for On-line Access From:
Aluminum Extruders Council
Aluminium Federation of South Africa
Australian Aluminium Council Ltd.
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Japan Aluminium Association
S.C. Alprom S.A, Romania

Revised: April 2006

Supersedes: April 2004

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CONTENTS

FOREWORD

Listed herein are designations and chemical composition limits for wrought aluminum and wrought aluminum alloys registered with The Aluminum Association. Numerical designations are assigned in accordance with the *Recommendation—International Designation System for Wrought Aluminum and Wrought Aluminum Alloys*, which is printed on pages 24 through 26. Additions may be made in accordance with the rules outlined in the Declaration of Accord printed on page 27, and alloys will be deleted when no longer in commercial use (see table of inactive alloys).

Since the International Designation System for Wrought Aluminum and Wrought Aluminum Alloys is based on USA's national standard "*American National Standard Alloy and Temper Designation System for Aluminum ANSI H35.1*," the system limits introduction of experimental alloy compositions to USA registrations. An experimental alloy registered by USA under this system is indicated by the prefix "X" and is subject to the following rules:

1. A composition shall not be designated as experimental ("X") for more than five years.
2. The "X" is dropped when the alloy is no longer experimental.
3. An experimental composition that is inactivated shall retain the prefix "X" for the duration of its inactive status. If reactivated, the "X" shall be removed.

Some of the registered alloys may be the subject of patent or patent applications, and their listing herein is not to be construed in any way as the granting of a license under such patent right.

A list of the organizations that are signatories to the Declaration of Accord on the Recommendation is printed on pages ii-iii.

SIGNATORIES TO THE DECLARATION OF ACCORD

The following organizations are signatories to the Declaration of Accord on an International Alloy Designation System for Wrought Aluminum and Wrought Aluminum Alloys which is printed on page 27 of this publication.

The Aluminum Association Inc. USA
900 19th Street, N.W.
Washington, D.C. 20006
USA
www.aluminum.org

All-Russian Institute of Aviation Materials (VIAM) RUSSIA
17 Radio Ulitza
105005 Moscow
RUSSIA
www.viam.ru

Aluminium Association of Canada CANADA
1010 Sherbrooke Street West, Suite 1600
Montreal, Quebec H3A2R7
CANADA
www.aac.aluminium.qc.ca

Aluminium Federation Limited UK
Broadway House, Calthorpe Road, Five Ways
Birmingham B15 1TN
UNITED KINGDOM
www.alfed.org.uk

Aluminium Federation of South Africa SOUTH AFRICA
P. O. Box 423
Isando, 1600
REPUBLIC OF SOUTH AFRICA
www.afsa.org.za

Aluminium – Verband Schweiz SWITZERLAND
Hallenstrasse 15
Postfach
CH-8024 Zurich
SWITZERLAND
www.alu.ch

Gesamtverband Der Aluminium-industrie e.V. (GDA) GERMANY
Am Bonneshof 5
D-40474 Dusseldorf
GERMANY
www.aluinfo.de

Associacao Brasileira Do Aluminio—ABAL BRAZIL
Rua Humberto 1, No. 220-4 Andar
Vila Mariana 04018-030
Sao Paulo-SP
BRAZIL
www.abal.org.br

The European Association of Aerospace Industries—Standardization A.E.C.M.A.
Gulledelle 98
B-1200 Bruxelles
BELGIUM
www.aecma.org

Assomet Associazione Nazionale Industrie Metalli Non Ferrosi ITALY
Centro Direzionale Ambrosizno—Pal. A/1
Via Del Missaglia, 97
20142 Milano
ITALY
www.assomet.it

Austrian Non-Ferrous Metals Federation AUSTRIA
Wiedner Hauptstrasse 63
Postfach 338
A-1045 Wien IV
AUSTRIA

Australian Aluminium Council Limited AUSTRALIA
Level 1, Dickson Square
P. O. Box 63
Dickson, ACT 2602
AUSTRALIA
www.aluminium.org.au

Aluminium Center Belgium BELGIUM
Z.I. Research Park 310
1731 Zellik
BELGIUM
www.aluminiumcenter.be

Centro Nacional de Investigaciones Metalurgicas (CENIM) SPAIN
Avda. Gregorio del Amo, 8
Ciudad Universitaria
28040 Madrid
SPAIN
www.cenim.csic.es

China Nonferrous Metals Techno-Economic Research Institute CHINA
No. 9 Xizhang Hutong, Xizhimennel Street
Beijing, 100035
PEOPLES REPUBLIC OF CHINA

European Aluminium Association EAA
Avenue de Broqueville, 12
B-1150 Brussels
BELGIUM
www.aluminium.org

FEDEM FRANCE
Federation Des Minerais, Mineraux Industriels Et Metaux Non Ferreux
17, rue Hamelin
75016 Paris
FRANCE
www.fedem.fr

Signatories (Continued)

IRAM—Instituto Argentino De Normalizacion — ARGENTINA
Peru 556
C1068AAB
Buenos Aires
ARGENTINA
www.iram.org.ar

Instituto Mexicano del Alumino, A.C. — MEXICO
Petarca 133-9 Piso
Col. Polanco
MEXICO, 11560, DF
www.imedal.com.mx

Institute of Non-Ferrous Metals — POLAND
Light Metals Divison
32-050 Skawina
Ul. Pi Lsudskiego 19
POLAND
www.imn.gliwice.pl

Japan Aluminium Association — JAPAN
Tsukamoto-Sozan Building
2-15, Ginza 4-Chome
Tokyo, Chuo-ku, 104-0061
JAPAN
www.aluminum.or.jp

S.C. Alprom S.A. — ROMANIA
1 Milcov Street
23007 Slatina, Olt County
ROMANIA

Swedish Aluminium Association — SWEDEN
P.O. Box 22307
SE-104 22
Stockholm
SWEDEN
www.svensktaluminium.com

VNMI – Association for the Dutch Metallurgic Industry — NETHERLANDS
P.O. Box 190
2700 AD Zoetermeer
NETHERLANDS
www.vnmi.nl

CHEMICAL COMPOSITION LIMITS[1,2]

Only composition limits which are identical to those listed herein for a registered designation are applicable to that designation.

NATURAL IMPURITY LIMITS FOR WROUGHT UNALLOYED ALUMINUM

REGISTERED INTERNATIONAL DESIGNATION No.[75]	DATE	BY	Si	Fe	Cu	Mn	Mg	Cr	Ni	Zn	Ti	Ga	V		OTHERS[39] Each	OTHERS[39] Total[3]	ALUMINUM Minimum
1050	1954-07-01	USA	0.25	0.40	0.05	0.05	0.05	----	----	0.05	0.03	----	0.05	----	0.03	----	99.50[4]
1050A	1972-09-22	EAA	0.25	0.40	0.05	0.05	0.05	----	----	0.07	0.05	----	----	----	0.03	----	99.50[4]
1060	1954-07-01	USA	0.25	0.35	0.05	0.03	0.03	----	----	0.05	0.03	----	0.05	----	0.03	----	99.60[4]
1065	1973-08-22	USA	0.25	0.30	0.05	0.03	0.03	----	----	0.05	0.03	----	0.05	----	0.03	----	99.65[4]
1070	1954-07-01	USA	0.20	0.25	0.04	0.03	0.03	----	----	0.04	0.03	----	0.05	----	0.03	----	99.70[4]
1070A	1972-09-22	EAA	0.20	0.25	0.03	0.03	0.03	----	----	0.07	0.03	----	----	----	0.03	----	99.70[4]
1080	1954-07-01	USA	0.15	0.15	0.03	0.02	0.02	----	----	0.03	0.03	0.03	0.05	----	0.02	----	99.80[4]
++ 1080A	1972-09-22	EAA	0.15	0.15	0.03	0.02	0.02	----	----	0.06	0.02	0.03	----	6	0.02	----	99.80[4]
1085	1954-07-01	USA	0.10	0.12	0.03	0.02	0.02	----	----	0.03	0.02	0.03	0.05	----	0.01	----	99.85[4]
1090	1954-07-01	USA	0.07	0.07	0.02	0.01	0.01	----	----	0.03	0.01	0.03	0.05	----	0.01	----	99.90[4]
1098	1972-02-15	GERMANY	0.010	0.006	0.003	----	----	----	----	0.015	0.003	----	----	----	0.003	----	99.98[5]

REGISTERED COMPOSITIONS

REGISTERED INTERNATIONAL DESIGNATION No.[75]	DATE	BY	Si	Fe	Cu	Mn	Mg	Cr	Ni	Zn	Ti	Ga	V		OTHERS[39] Each	OTHERS[39] Total[3]	ALUMINUM Minimum
1100	1954-07-01	USA	0.95 Si + Fe		0.05-0.20	0.05	----	----	----	0.10	----	----	----	8	0.05	0.15	99.00[4]
+ 1100A	2005-06-29	JAPAN	1.00 Si + Fe		0.05-0.20	0.05	0.10	----	----	0.10	0.10	----	----	----	0.05	0.15	99.00[4]
1200	1988-09-23	USA	1.00 Si + Fe		0.05	0.05	----	----	----	0.10	0.05	----	----	----	0.05	0.15	99.00[4]
1200A	1991-03-22	NORWAY	1.00 Si + Fe		0.10	0.30	0.30	0.10	----	0.10	----	----	----	----	0.05	0.15	99.00[4]
1300[88]	2000-12-13	FRANCE	0.20	0.30	0.05	0.03	0.03	----	----	0.20-0.50	0.03	----	----	----	0.05	0.15	99.00[4]
1110	1987-06-15	FRANCE	0.30	0.8	0.04	0.01	0.25	0.01	----	----	----	----	----	0.02 B, 0.03 V+Ti	0.03	----	99.10[4]
1120	1982-07-07	AUSTRALIA	0.10	0.40	0.05-0.35	0.01	0.20	0.01	----	0.05	----	0.03	----	0.05 B, 0.02 V+Ti	0.03	0.10	99.20[4]
1230[86]	1954-07-01	USA	0.70 Si + Fe		0.10	0.05	0.05	----	----	0.10	0.03	----	0.05	----	0.03	----	99.30[4]
+ 1230A	2005-06-29	JAPAN	0.70 Si + Fe		0.10	0.05	0.05	----	----	0.05	----	----	----	----	0.03	----	99.30[4]
1235	1954-07-01	USA	0.65 Si + Fe		0.05	0.05	0.05	----	----	0.10	0.06	----	0.05	----	0.03	----	99.35[4]
1435	1958-03-05	USA	0.15	0.30-0.50	0.02	0.05	0.05	----	----	0.10	0.03	----	0.05	----	0.03	----	99.35[4]
1145	1954-07-01	USA	0.55 Si + Fe		0.05	0.05	0.05	----	----	0.05	0.03	----	0.05	----	0.03	----	99.45[4]
1345	1956-10-08	USA	0.30	0.40	0.10	0.05	0.05	----	----	0.05	0.03	----	0.05	----	0.03	----	99.45[4]
1445	1973-09-14	AUSTRALIA	0.50 Si + Fe[20]		0.04[20]	----	----	----	----	----	----	----	----	----	----	0.05	99.45[4]
1150	1973-08-02	AUSTRALIA	0.45 Si + Fe		0.05-0.20	0.05	0.05	----	----	0.05	0.03	----	—	----	0.03	----	99.50[4]
1350[12]	1975-01-24	USA	0.10	0.40	0.05	0.01	----	0.01	----	0.05	----	0.03	----	0.05 B, 0.02 V+Ti	0.03	0.10	99.50[4]
1350A	1979-02-15	GERMANY	0.25	0.40	0.02	----	0.05	----	----	0.05	----	----	----	0.03 Cr+Mn+Ti+V	0.03	----	99.50[4]
++ 1450	1980-11-14	EAA	0.25	0.40	0.05	0.05	0.05	----	----	0.07	0.10-0.20	----	----	6	0.03	----	99.50[4]

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See footnotes on pages 13-14.

CHEMICAL COMPOSITION LIMITS[1,2]

REGISTERED COMPOSITION–Continued

Only composition limits which are identical to those listed herein for a registered designation are applicable to that designation.

REGISTERED INTERNATIONAL DESIGNATION															OTHERS[39]		ALUMINUM
No.[75]	DATE	BY	Si	Fe	Cu	Mn	Mg	Cr	Ni	Zn	Ti	Ga	V		Each	Total[3]	Minimum
1370	1976-04-20	FRANCE	0.10	0.25	0.02	0.01	0.02	0.01	...	0.04	...	0.03	...	0.02 B, 0.02 V+Ti	0.02	0.10	99.70[4]
1275	1986-03-24	SPAIN	0.08	0.12	0.05-0.10	0.02	0.02	...	...	0.03	0.02	0.03	0.03	...	0.01	...	99.75[4]
1185	1954-07-01	USA	0.15 Si + Fe		0.01	0.02	0.02	...	...	0.03	0.02	0.03	0.05	...	0.01	...	99.85[4]
1285	1954-07-01	USA	0.08[7]	0.08[7]	0.02	0.01	0.01	...	...	0.03	0.02	0.03	0.05	...	0.01	...	99.85[4]
1385	1987-06-15	FRANCE	0.05	0.12	0.02	0.01	0.02	0.01	...	0.03	...	0.03	...	0.03 V+Ti[40]	0.01	...	99.85[4]
1188	1954-07-01	USA	0.06	0.06	0.005	0.01	0.01	...	...	0.03	0.01	0.03	0.05	8	0.01	...	99.88[4]
1190	1987-06-15	FRANCE	0.05	0.07	0.01	0.01	0.01	0.01	...	0.02	...	0.02	...	0.01 V+Ti[41]	0.01	...	99.90[4]
1290	2005-06-29	JAPAN	0.050	0.030	0.050	...	...	...	...	...	...	...	...	...	0.01	...	99.90[5]
1193	1964-09-29	USA	0.04	0.04	0.006	0.01	0.01	...	...	0.03	0.01	0.03	0.05	...	0.01	...	99.93[4]
1198	1990-10-04	FRANCE	0.010	0.006	0.006	0.006	...	...	...	0.010	0.006	0.006	...	...	0.003	...	99.98[4]
1199	1956-03-12	USA	0.006	0.006	0.006	0.002	0.006	...	...	0.006	0.002	0.005	0.005	...	0.002	...	99.99[5]
2001	1979-08-22	FRANCE	0.20	0.20	5.2-6.0	0.15-0.50	0.20-0.45	0.10	0.05	0.10	0.20	...	...	0.05 Zr[42]	0.05	0.15	Remainder
2002	1975-06-25	FRANCE	0.35-0.8	0.30	1.5-2.5	0.20	0.50-1.0	0.20	...	0.20	0.20	...	...	...	0.05	0.15	Remainder
2004	1980-08-07	UK	0.20	0.20	5.5-6.5	0.10	0.50	...	...	0.10	0.05	...	...	0.30-0.50 Zr	0.05	0.15	Remainder
2005	1983-01-10	ARGENTINA	0.8	0.7	3.5-5.0	1.0	0.20-1.0	0.10	0.20	0.50	0.20	...	...	0.20 Bi, 1.0-2.0 Pb	0.05	0.15	Remainder
2006	1983-01-10	ARGENTINA	0.6-1.3	0.7	1.0-2.0	0.6-1.0	0.50-1.4	...	0.20	0.20	0.30	...	...	...	0.05	0.15	Remainder
2007	1979-02-15	GERMANY	0.8	0.8	3.3-4.6	0.50-1.0	0.40-1.8	0.10	0.20	0.8	0.20	...	...	26	0.10	0.30	Remainder
2007A	2001-02-21	ITALY	0.8	0.8	3.3-4.6	0.20-1.0	0.40-1.8	0.10	0.20	0.8	0.20	...	...	60	0.10	0.30	Remainder
2008	1987-07-01	USA	0.50-0.8	0.40	0.7-1.1	0.30	0.25-0.50	0.10	...	0.25	0.10	...	0.05	...	0.05	0.15	Remainder
2009	1990-01-24	USA	0.25	0.05	3.2-4.4	...	1.0-1.6	...	...	0.10	...	...	...	44	0.05	0.15	Remainder
2010	1990-09-21	USA	0.50	0.50	0.7-1.3	0.10-0.40	0.40-1.0	0.15	...	0.30	...	...	...	...	0.05	0.15	Remainder
2011	1954-07-01	USA	0.40	0.7	5.0-6.0	...	...	...	...	0.30	...	...	...	8	0.05	0.15	Remainder
2011A	1982-02-11	SWITZERLAND	0.40	0.50	4.5-6.0	...	...	...	...	0.30	...	...	...	8	0.05	0.15	Remainder
2111	1993-07-07	USA	0.40	0.7	5.0-6.0	...	...	...	...	0.30	...	...	...	64	0.05	0.15	Remainder
2111A	2001-02-21	ITALY	0.40	0.7	5.0-6.0	0.15	0.15	...	...	0.30	0.05	...	...	68	0.05	0.15	Remainder
2111B	2001-09-05	SWITZERLAND	0.30	0.50	4.6-6.0	0.05	0.05	...	...	...	...	...	...	70	0.05	0.15	Remainder
2012	1993-06-23	USA	0.40	0.7	4.0-5.5	...	...	...	...	0.30	...	...	...	83	0.05	0.15	Remainder
2013	2003-05-20	JAPAN	0.6-1.0	0.40	1.5-2.0	0.25	0.8-1.2	0.04-0.35	...	0.25	0.15	...	...	...	0.05	0.15	Remainder
2014	1954-07-01	USA	0.50-1.2	0.7	3.9-5.0	0.40-1.2	0.20-0.8	0.10	...	0.25	0.15	...	...	9	0.05	0.15	Remainder
2014A	1976-08-30	AECMA	0.50-0.9	0.50	3.9-5.0	0.40-1.2	0.20-0.8	0.10	0.10	0.25	0.15	...	...	0.20 Zr+Ti	0.05	0.15	Remainder
2214	1954-07-01	USA	0.50-1.2	0.30	3.9-5.0	0.40-1.2	0.20-0.8	0.10	...	0.25	0.15	...	...	9	0.05	0.15	Remainder
2015	2003-06-24	SWITZERLAND	0.8	0.8	3.9-5.2	0.30-1.0	0.30-1.3	0.15	0.20	0.7	0.20	...	...	71	0.05	0.15	Remainder
2016	2003-11-14	GERMANY	0.30-0.7	0.15	3.5-4.5	0.10-0.50	0.30-0.8	...	...	...	0.05-0.15	...	...	73	0.05	0.15	Remainder
2017	1954-07-01	USA	0.20-0.8	0.7	3.5-4.5	0.40-1.0	0.40-0.8	0.10	...	0.25	0.15	...	...	9	0.05	0.15	Remainder
2017A	1972-09-22	EAA	0.20-0.8	0.7	3.5-4.5	0.40-1.0	0.40-1.0	0.10	...	0.25	...	...	...	0.25 Zr+Ti	0.05	0.15	Remainder
2117	1954-07-01	USA	0.8	0.7	2.2-3.0	0.20	0.20-0.50	0.10	...	0.25	...	...	...	...	0.05	0.15	Remainder
2018	1954-07-01	USA	0.9	1.0	3.5-4.5	0.20	0.45-0.9	0.10	1.7-2.3	0.25	...	...	...	...	0.05	0.15	Remainder
2218	1954-07-01	USA	0.9	1.0	3.5-4.5	0.20	1.2-1.8	0.10	1.7-2.3	0.25	...	...	...	...	0.05	0.15	Remainder
2618	1954-07-01	USA	0.10-0.25	0.9-1.3	1.9-2.7	...	1.3-1.8	...	0.9-1.2	0.10	0.04-0.10	...	...	...	0.05	0.15	Remainder
2618A	1972-09-22	EAA	0.15-0.25	0.9-1.4	1.8-2.7	0.25	1.2-1.8	...	0.8-1.4	0.15	0.20	...	...	0.25 Zr+Ti	0.05	0.15	Remainder

See footnotes on pages 13-14.

CHEMICAL COMPOSITION LIMITS[1,2]

REGISTERED COMPOSITION—Continued

Only composition limits which are identical to those listed herein for a registered designation are applicable to that designation.

	REGISTERED INTERNATIONAL DESIGNATION															OTHERS[38]		ALUMINUM
	No.[75]	DATE	BY	Si	Fe	Cu	Mn	Mg	Cr	Ni	Zn	Ti	Ga	V		Each	Total[3]	Minimum
	2219[16]	1954-08-13	USA	0.20	0.30	5.8-6.8	0.20-0.40	0.02	...	...	0.10	0.02-0.10	...	0.05-0.15	0.10-0.25 Zr	0.05	0.15	Remainder
	2319	1958-06-05	USA	0.20	0.30	5.8-6.8	0.20-0.40	0.02	...	...	0.10	0.10-0.20	...	0.05-0.15	0.10-0.25 Zr[6]	0.05	0.15	Remainder
	2419	1972-10-12	USA	0.15	0.18	5.8-6.8	0.20-0.40	0.02	...	...	0.10	0.02-0.10	...	0.05-0.15	0.10-0.25 Zr	0.05	0.15	Remainder
	2519	1985-02-07	USA	0.25[28]	0.30[28]	5.3-6.4	0.10-0.50	0.05-0.40	...	...	0.10	0.02-0.10	...	0.05-0.15	0.10-0.25 Zr	0.05	0.15	Remainder
	2021	1981-05-28	UK	0.20	0.30	5.8-6.8	0.20-0.40	0.02	...	...	0.10	0.02-0.10	...	0.05-0.15	0.10-0.25 Zr[29]	0.05	0.15	Remainder
•	2022	2004-08-17	FRANCE	0.15	0.20	4.5-5.5	0.15-0.50	0.10-0.45	0.05	...	0.05-0.30	0.15	...	...	...	0.05	0.15	Remainder
•	2023	2004-08-17	FRANCE	0.10	0.15	3.6-4.5	0.30	1.0-1.6	0.10	...	...	0.05	...	...	0.05-0.15 Zr[58]	0.05	0.15	Remainder
	2024	1954-07-01	USA	0.50	0.50	3.8-4.9	0.30-0.9	1.2-1.8	0.10	...	0.25	0.15	...	...	9	0.05	0.15	Remainder
	2024A	1996-02-14	FRANCE	0.15	0.20	3.7-4.5	0.15-0.8	1.2-1.5	0.10	...	0.25	0.15	...	...	...	0.05	0.15	Remainder
	2124	1970-10-02	USA	0.20	0.30	3.8-4.9	0.30-0.9	1.2-1.8	0.10	...	0.25	0.15	...	...	9	0.05	0.15	Remainder
	2224	1978-05-04	USA	0.12	0.15	3.8-4.4	0.30-0.9	1.2-1.8	0.10	...	0.25	0.15	...	...	...	0.05	0.15	Remainder
	2224A	1997-10-10	RUSSIA	0.10	0.15	3.8-4.5	0.40-0.8	1.2-1.6	...	0.05	0.10	0.01-0.07	...	...	...	0.05	0.15	Remainder
	2324	1978-05-04	USA	0.10	0.12	3.8-4.4	0.30-0.9	1.2-1.8	0.10	...	0.25	0.15	...	...	...	0.05	0.15	Remainder
	2424	1994-01-28	USA	0.10	0.12	3.8-4.4	0.30-0.6	1.2-1.6	...	...	0.20	0.10	...	...	...	0.05	0.15	Remainder
	2524	1995-11-20	USA	0.06	0.12	4.0-4.5	0.45-0.7	1.2-1.6	0.05	...	0.15	0.10	...	...	...	0.05	0.15	Remainder
	2025	1954-07-01	USA	0.50-1.2	1.0	3.9-5.0	0.40-1.2	0.05	0.10	...	0.25	0.15	...	...	...	0.05	0.15	Remainder
	2026	1999-05-24	USA	0.05	0.07	3.6-4.3	0.30-0.8	1.0-1.6	...	...	0.10	0.06	...	...	0.05-0.25 Zr	0.05	0.15	Remainder
	2027	2001-12-19	FRANCE	0.12	0.15	3.9-4.9	0.50-1.2	1.0-1.5	...	...	0.20	0.08	...	...	0.05-0.15 Zr	0.05	0.15	Remainder
•	2028	2005-07-08	GERMANY	0.8	0.8	3.3-4.6	0.50-1.0	0.40-1.8	0.10	0.20	0.8	0.20	...	...	76	0.10	0.30	Remainder
	2030	1972-09-22	EAA	0.8	0.7	3.3-4.5	0.20-1.0	0.50-1.3	0.10	...	0.50	0.20	...	...	0.20 Bi, 0.8-1.5 Pb	0.10	0.30	Remainder
	2031	1974-02-05	UK	0.50-1.3	0.6-1.2	1.8-2.8	0.50	0.6-1.2	...	0.6-1.4	0.20	0.20	...	...	...	0.05	0.15	Remainder
•	2032	2005-06-29	JAPAN	0.50-1.3	0.6-1.5	1.5-2.5	0.20	1.2-1.8	...	0.6-1.4	0.20	0.20	...	...	...	0.05	0.15	Remainder
	2034	1983-01-18	USA	0.10	0.12	4.2-4.8	0.8-1.3	1.3-1.9	0.05	...	0.20	0.15	...	...	0.08-0.15 Zr	0.05	0.15	Remainder
	2036	1970-08-13	USA	0.50	0.50	2.2-3.0	0.10-0.40	0.30-0.6	0.10	...	0.25	0.15	...	...	...	0.05	0.15	Remainder
	2037	1977-06-01	USA	0.50	0.50	1.4-2.2	0.10-0.40	0.30-0.8	0.10	...	0.25	0.15	...	0.05	...	0.05	0.15	Remainder
	2038	1980-09-23	USA	0.50-1.3	0.6	0.8-1.8	0.10-0.40	0.40-1.0	0.20	...	0.50	0.15	0.05	0.05	...	0.05	0.15	Remainder
	2039	1999-03-17	SWITZERLAND	0.20	0.30	4.5-5.5	0.20-0.50	0.40-0.8	...	...	...	0.15	...	...	0.10-0.25 Zr[21]	0.05	0.15	Remainder
•	2139	2004-10-07	FRANCE	0.10	0.15	4.5-5.5	0.20-0.6	0.20-0.8	0.05	...	0.25	0.15	...	0.05	77	0.05	0.15	Remainder
	2040	2003-10-30	USA	0.08	0.10	4.8-5.4	0.45-0.8	0.7-1.1	...	...	0.25	0.06	...	...	74	0.05	0.15	Remainder
•	2050	2004-06-02	USA	0.08	0.10	3.2-3.9	0.20-0.50	0.20-0.6	0.05	0.05	0.25	0.10	0.05	0.05	0.06-0.14 Zr[78]	0.05	0.15	Remainder
	2056	2003-02-18	FRANCE	0.10	0.12	3.3-4.3	0.10-0.50	0.6-1.4	...	...	0.40-0.8	...	...	...	...	0.05	0.15	Remainder
	2080	1984-08-06	USA	0.10	0.12	2.4-3.0	0.05	0.25	0.05	...	0.10	0.15	...	...	0.08-0.15 Zr[30]	0.05	0.15	Remainder
	2091	1985-08-03	FRANCE	0.20	0.30	1.8-2.5	0.10	1.1-1.9	0.10	...	0.25	0.10	...	...	0.04-0.16 Zr[35]	0.05	0.15	Remainder
	2094	1990-08-04	USA	0.12	0.15	4.4-5.2	0.25	0.25-0.8	...	...	0.25	0.10	...	...	0.04-0.18 Zr[46]	0.05	0.15	Remainder
	2095	1990-08-04	USA	0.12	0.15	3.9-4.6	0.25	0.25-0.8	...	...	0.25	0.10	...	...	0.04-0.18 Zr[47]	0.05	0.15	Remainder
	2195	1992-11-20	USA	0.12	0.15	3.7-4.3	0.25	0.25-0.8	...	...	0.25	0.10	...	...	0.08-0.16 Zr[53]	0.05	0.15	Remainder
	2196	2000-12-08	USA	0.12	0.15	2.5-3.3	0.35	0.25-0.8	...	...	0.35	0.10	...	...	0.04-0.18 Zr[27]	0.05	0.15	Remainder
	2097	1993-06-30	USA	0.12	0.15	2.5-3.1	0.10-0.6	0.35	...	...	0.35	0.15	...	...	0.08-0.16 Zr[41]	0.05	0.15	Remainder
	2197	1993-09-21	USA	0.10	0.10	2.5-3.1	0.10-0.50	0.25	...	...	0.05	0.12	...	...	0.08-0.15 Zr[42]	0.05	0.15	Remainder
	2297	1997-08-18	USA	0.10	0.10	2.5-3.1	0.10-0.50	0.25	...	...	0.05	0.12	...	...	0.08-0.15 Zr[65]	0.05	0.15	Remainder
	2397	2002-04-03	USA	0.10	0.10	2.5-3.1	0.10-0.50	0.25	...	...	0.05-0.15	0.12	...	...	0.08-0.15 Zr[65]	0.05	0.15	Remainder
	2098	2000-06-22	USA	0.12	0.15	3.2-3.8	0.35	0.25-0.8	...	...	0.35	0.10	...	...	0.04-0.18 Zr[34]	0.05	0.15	Remainder
•	2198	2005-10-06	USA	0.08	0.10	2.9-3.5	0.50	0.25-0.8	0.05	...	0.35	0.10	...	...	0.04-0.18 Zr[84]	0.05	0.15	Remainder
	2099	2003-08-22	USA	0.05	0.07	2.4-3.0	0.10-0.50	0.10-0.50	...	...	0.40-1.0	0.10	...	...	48	0.05	0.15	Remainder
•	2199	2005-06-01	USA	0.05	0.07	2.3-2.9	0.10-0.50	0.05-0.40	...	...	0.20-0.9	0.10	...	...	0.05-0.12 Zr[79]	0.05	0.12	Remainder

See footnotes on pages 13-14.

CHEMICAL COMPOSITION LIMITS[1,2]

REGISTERED COMPOSITION—Continued

Only composition limits which are identical to those listed herein for a registered designation are applicable to that designation.

REGISTERED INTERNATIONAL DESIGNATION															OTHERS[30]		ALUMINUM
No.[7]	DATE	BY	Si	Fe	Cu	Mn	Mg	Cr	Ni	Zn	Ti	Ga	V		Each	Total[3]	Minimum
3002	1961-07-03	USA	0.08	0.10	0.15	0.05-0.25	0.05-0.20	---	---	0.05	0.03	---	0.05	---	0.03	0.10	Remainder
3102	1972-03-01	USA	0.40	0.7	0.10	0.05-0.40	---	---	---	0.30	0.10	---	---	---	0.05	0.15	Remainder
3003	1954-07-01	USA	0.6	0.7	0.05-0.20	1.0-1.5	---	---	---	0.10	---	---	---	---	0.05	0.15	Remainder
‡‡ 3103	1972-09-22	EAA	0.50	0.7	0.10	0.9-1.5	0.30	0.10	---	0.20	---	---	---	0.10 Zr+Ti[6]	0.05	0.15	Remainder
3103A	1991-03-22	NORWAY	0.50	0.7	0.10	0.7-1.4	0.30	0.10	---	0.20	0.10	---	---	0.10 Zr+Ti	0.05	0.15	Remainder
3103B	2002-04-05	USA	0.50-1.3	0.8	0.50	0.7-1.3	0.50	---	---	0.50	0.20	---	---	---	0.05	0.15	Remainder
3203	1973-06-22	AUSTRALIA	0.6	0.7	0.05	1.0-1.5	---	---	---	0.10	---	---	---	6	0.05	0.15	Remainder
3403	2001-05-14	USA	1.3	0.8	0.50	0.8-1.5	0.6	0.10	---	0.40	0.10	---	---	---	0.05	0.15	Remainder
3004	1954-07-01	USA	0.30	0.7	0.25	1.0-1.5	0.8-1.3	---	---	0.25	---	---	---	---	0.05	0.15	Remainder
3004A	1985-07-09	AUSTRALIA	0.40	0.7	0.25	0.8-1.5	0.8-1.5	0.10	---	0.25	0.05	---	---	0.03 Pb	0.05	0.15	Remainder
3104	1978-08-30	USA	0.6	0.8	0.05-0.25	0.8-1.4	0.8-1.3	---	---	0.25	0.10	0.05	0.05	---	0.05	0.15	Remainder
3204	1991-07-11	USA	0.30	0.7	0.10-0.25	0.8-1.5	0.8-1.5	---	---	0.25	---	---	---	---	0.05	0.15	Remainder
3304	2001-05-14	USA	0.7	0.8	0.6	0.8-1.4	0.8-1.4	0.10	---	0.40	0.10	---	---	---	0.05	0.15	Remainder
3005	1954-07-01	USA	0.6	0.7	0.30	1.0-1.5	0.20-0.6	0.10	---	0.25	0.10	---	---	---	0.05	0.15	Remainder
3005A	1997-06-12	NORWAY	0.7	0.8	0.30	1.0-1.5	0.20-0.6	0.10	---	0.40	0.10	---	---	---	0.05	0.15	Remainder
3105	1960-05-27	USA	0.6	0.7	0.30	0.30-0.8	0.20-0.8	0.20	---	0.40	0.10	---	---	---	0.05	0.15	Remainder
3105A	1990-10-04	FRANCE	0.6	0.7	0.30	0.30-0.8	0.20-0.8	0.20	---	0.25	0.10	---	---	---	0.05	0.15	Remainder
3105B	1997-06-12	NORWAY	0.7	0.9	0.30	0.30-0.8	0.20-0.8	0.20	---	0.50	0.10	---	---	0.10 Pb	0.05	0.15	Remainder
3007	1976-03-17	USA	0.50	0.7	0.05-0.30	0.30-0.8	0.6	0.20	---	0.40	0.10	---	---	---	0.05	0.15	Remainder
3107	1977-11-11	SPAIN	0.6	0.7	0.05-0.15	0.40-0.9	---	---	---	0.20	0.10	---	---	---	0.05	0.15	Remainder
3207	1979-02-15	GERMANY	0.30	0.45	0.10	0.40-0.8	0.10	---	---	0.10	---	---	---	---	0.05	0.10	Remainder
3207A	1990-11-28	NORWAY	0.35	0.6	0.25	0.30-0.8	0.40	0.20	---	0.25	---	---	---	---	0.05	0.15	Remainder
3307	1986-08-20	USA	0.6	0.8	0.30	0.50-0.9	0.30	0.20	---	0.40	0.10	---	---	---	0.05	0.15	Remainder
3009	1978-03-03	GERMANY	1.0-1.8	0.7	0.10	1.2-1.8	0.10	0.05	0.05	0.05	0.10	---	---	0.10 Zr	0.05	0.15	Remainder
3010	1978-08-25	USA	0.10	0.20	0.03	0.20-0.9	---	0.05-0.40	---	0.05	0.05	---	0.05	---	0.03	0.10	Remainder
3011	1978-08-25	USA	0.40	0.7	0.05-0.20	0.8-1.2	---	0.10-0.40	---	0.10	0.10	---	---	0.10-0.30 Zr	0.05	0.15	Remainder
• 3110	2004-06-10	USA	0.25	0.05-0.35	0.05	0.30-0.7	0.05	0.05-0.25	...	0.05	0.05-0.30	...	...	...	0.05	0.15	Remainder
3012	1983-01-10	ARGENTINA	0.6	0.7	0.10	0.50-1.1	0.10	0.20	---	0.10	0.10	---	---	---	0.05	0.15	Remainder
3013	1983-01-10	ARGENTINA	0.6	1.0	0.50	0.9-1.4	0.20-0.6	---	---	0.50-1.0	---	---	---	---	0.05	0.15	Remainder
3014	1983-01-10	ARGENTINA	0.6	1.0	0.50	1.0-1.5	0.10	---	---	0.50-1.0	0.10	---	---	---	0.05	0.15	Remainder
3015	1986-08-20	USA	0.6	0.8	0.30	0.50-0.9	0.20-0.7	0.10	---	0.25	0.10	---	---	---	0.05	0.15	Remainder
3016	1986-08-20	USA	0.6	0.8	0.30	0.50-0.9	0.50-0.8	0.10	---	0.25	0.10	---	---	---	0.05	0.15	Remainder
3017	1989-08-03	NETHERLANDS	0.25	0.25-0.45	0.25-0.40	0.8-1.2	0.10	0.15	---	0.10	0.05	---	---	---	0.05	0.15	Remainder
3019	2000-01-11	ROMANIA	0.6	0.7	0.9	0.30-0.9	0.20-0.9	0.20	0.10	0.20-0.9	0.10	---	---	---	0.05	0.15	Remainder
3020	1996-04-17	USA	0.50	0.6	0.10	0.6-1.2	0.20	0.20	---	0.05-0.50	0.05-0.25	---	---	---	0.05	0.15	Remainder
3025	1997-04-03	USA	0.6	0.50-0.9	0.30	0.40-1.0	0.20-0.8	0.20	0.05	0.25	0.10	---	---	---	0.05	0.15	Remainder
3026	2003-04-09	USA	0.25	0.10-0.40	0.05	0.40-0.9	0.10	0.05	---	0.05-0.30	0.05-0.30	---	---	---	0.05	0.15	Remainder
3030	1996-09-09	USA	0.15	0.35	0.10	0.10-0.7	0.05	0.05	---	0.05-0.50	0.05-0.35	---	---	---	0.05	0.15	Remainder
3130	2002-07-09	USA	0.15	0.20	0.05	0.10-0.40	0.05	---	---	0.05-0.30	0.05	---	---	---	0.05	0.15	Remainder

See footnotes on pages 13-14.

CHEMICAL COMPOSITION LIMITS[1,2]

REGISTERED COMPOSITION–Continued

Only composition limits which are identical to those listed herein for a registered designation are applicable to that designation.

REGISTERED INTERNATIONAL DESIGNATION															OTHERS[39]		ALUMINUM
No.[75]	DATE	BY	Si	Fe	Cu	Mn	Mg	Cr	Ni	Zn	Ti	Ga	V		Each	Total[3]	Minimum
4004[65]	1971-10-06	USA	9.0-10.5	0.8	0.25	0.10	1.0-2.0	...	...	0.20	...	...	...	...	0.05	0.15	Remainder
4104	1974-02-26	USA	9.0-10.5	0.8	0.25	0.10	1.0-2.0	...	...	0.20	...	...	...	0.02-0.20 Bi	0.05	0.15	Remainder
4006	1977-04-06	FRANCE	0.8-1.2	0.50-0.8	0.10	0.05	0.01	0.20	...	0.05	...	...	...	...	0.05	0.15	Remainder
4007	1978-12-12	FRANCE	1.0-1.7	0.40-1.0	0.20	0.8-1.5	0.20	0.05-0.25	0.15-0.7	0.10	0.10	...	...	0.05 Co	0.05	0.15	Remainder
4008	1985-05-15	USA	6.5-7.5	0.09	0.05	0.05	0.30-0.45	...	...	0.05	0.04-0.15	...	...	6	0.05	0.15	Remainder
4009	1987-05-26	USA	4.5-5.5	0.20	1.0-1.5	0.10	0.45-0.6	...	...	0.10	0.20	...	...	6	0.05	0.15	Remainder
4010	1988-07-11	USA	6.5-7.5	0.20	0.20	0.10	0.30-0.45	...	...	0.10	0.20	...	...	6	0.05	0.15	Remainder
4013	1988-07-26	USA	3.5-4.5	0.35	0.05-0.20	0.03	0.05-0.20	...	...	0.05	0.02	...	...	42	0.05	0.15	Remainder
4014	1989-07-04	NORWAY	1.4-2.2	0.7	0.20	0.35	0.30-0.8	...	...	0.20	...	...	...	...	0.05	0.15	Remainder
4015	1989-07-04	NORWAY	1.4-2.2	0.7	0.20	0.6-1.2	0.10-0.50	...	...	0.20	...	...	...	...	0.05	0.15	Remainder
4016	1993-02-23	NORWAY	1.4-2.2	0.7	0.20	0.6-1.2	0.10	...	...	0.50-1.3	...	...	...	...	0.05	0.15	Remainder
4017	1995-06-25	NORWAY	0.6-1.6	0.7	0.10-0.50	0.6-1.2	0.10-0.50	...	...	0.20	...	...	...	...	0.05	0.15	Remainder
++ 4018	1995-12-15	GERMANY	6.5-7.5	0.20	0.05	0.10	0.50-0.8	...	...	0.10	0.20	...	...	6	0.05	0.15	Remainder
4019	1999-04-09	UK	18.5-21.5	4.5-5.4	...	...	...	...	1.8-2.2	...	...	...	...	...	0.05	0.15	Remainder
+ 4020	2005-03-31	AUSTRIA	2.5-3.5	0.20	0.03	0.8-1.2	0.01	0.01	...	...	0.005	...	...	0.01 Zr[6, 60]	0.02	0.10	Remainder
4026	2001-04-02	USA	9.0-11.5	0.50	2.5-3.5	...	0.7-1.4	...	...	0.10	0.05	...	...	1.0-2.0 Bi	0.05	0.15	Remainder
4032	1954-07-01	USA	11.0-13.5	1.0	0.50-1.3	...	0.8-1.3	0.10	0.50-1.3	0.25	...	...	...	...	0.05	0.15	Remainder
4043	1954-07-01	USA	4.5-6.0	0.8	0.30	0.05	0.05	...	...	0.10	0.20	...	...	6	0.05	0.15	Remainder
4043A	1976-02-03	EAA	4.5-6.0	0.6	0.30	0.15	0.20	...	...	0.10	0.15	...	...	6	0.05	0.15	Remainder
4343	1954-07-01	USA	6.8-8.2	0.8	0.25	0.10	...	...	...	0.20	...	...	...	...	0.05	0.15	Remainder
4643	1963-08-14	USA	3.6-4.6	0.8	0.10	0.05	0.10-0.30	...	...	0.10	0.15	...	...	6	0.05	0.15	Remainder
4044[66]	1969-07-15	USA	7.8-9.2	0.8	0.25	0.10	...	...	...	0.20	...	...	...	...	0.05	0.15	Remainder
4045	1964-07-01	USA	9.0-11.0	0.8	0.30	0.05	0.05	...	...	0.10	0.20	...	...	...	0.05	0.15	Remainder
4145	1957-04-30	USA	9.3-10.7	0.8	3.3-4.7	0.15	0.15	0.15	...	0.20	...	...	...	6	0.05	0.15	Remainder
4145A	1976-05-28	UK	9.0-11.0	0.6	3.0-5.0	0.15	0.10	...	...	0.20	0.15	...	...	6	0.05	0.15	Remainder
++ 4046	1990-11-14	EAA	9.0-11.0	0.50	0.03	0.40	0.20-0.50	...	...	0.10	0.15	...	...	6	0.05	0.15	Remainder
4047	1964-07-01	USA	11.0-13.0	0.8	0.30	0.15	0.10	...	...	0.20	...	...	...	6	0.05	0.15	Remainder
4047A	1976-02-03	EAA	11.0-13.0	0.6	0.30	0.15	0.10	...	...	0.20	0.15	...	...	6	0.05	0.15	Remainder
4147	1969-04-24	USA	11.0-13.0	0.8	0.25	0.10	0.10-0.50	...	...	0.20	...	...	...	6	0.05	0.15	Remainder
5005	1954-07-01	USA	0.30	0.7	0.20	0.20	0.50-1.1	0.10	...	0.25	...	...	...	...	0.05	0.15	Remainder
5005A	1979-02-15	GERMANY	0.30	0.45	0.05	0.15	0.7-1.1	0.10	...	0.20	...	...	...	...	0.05	0.15	Remainder
5205	1967-05-29	USA	0.15	0.7	0.03-0.10	0.10	0.6-1.0	0.10	...	0.05	...	...	...	...	0.05	0.15	Remainder
5305	1990-11-14	EAA	0.08	0.08	...	0.03	0.7-1.1	...	...	0.05	0.02	...	...	...	0.02	...	Remainder
5505	1990-11-14	EAA	0.06	0.04	...	0.03	0.8-1.1	...	...	0.04	0.01	...	...	...	0.01	...	Remainder
5605	1990-11-14	EAA	0.01	0.008	...	...	0.8-1.1	...	...	0.01	0.008	...	...	0.008 Fe+Ti	0.003	...	Remainder

See footnotes on pages 13-14.

CHEMICAL COMPOSITION LIMITS[1,2]

REGISTERED COMPOSITION–Continued

Only composition limits which are identical to those listed herein for a registered designation are applicable to that designation.

	REGISTERED INTERNATIONAL DESIGNATION															OTHERS[30]		ALUMINUM
	No.[31]	DATE	BY	Si	Fe	Cu	Mn	Mg	Cr	Ni	Zn	Ti	Ga	V		Each	Total[3]	Minimum
	5006	1977-06-08	USA	0.40	0.8	0.10	0.40-0.8	0.8-1.3	0.10	----	0.25	0.10	----	----	----	0.05	0.15	Remainder
	5106	2001-06-11	USA	0.40	0.7	0.30	0.40-0.7	0.8-1.2	0.10	----	0.10	0.10	----	----	----	0.05	0.15	Remainder
	5010	1961-10-03	USA	0.40	0.7	0.25	0.10-0.30	0.20-0.6	0.15	----	0.30	0.10	----	----	----	0.05	0.15	Remainder
	5110	1990-11-14	EAA	0.08	0.08	----	0.03	0.30-0.6	----	----	0.05	0.02	----	----	----	0.02	----	Remainder
+	5110A	2005-06-29	JAPAN	0.15	0.25	0.20	0.20	0.20-0.6	----	----	0.03	----	----	----	----	0.05	0.10	Remainder
	5210	1990-11-14	EAA	0.06	0.04	----	0.03	0.35-0.6	----	----	0.04	0.01	----	----	----	0.01	----	Remainder
	5310	1990-11-14	EAA	0.01	0.008	----	----	0.35-0.6	----	----	0.01	0.008	----	----	0.008 Fe+Ti	0.003	----	Remainder
	5016	1982-09-17	USA	0.25	0.6	0.20	0.40-0.7	1.4-1.9	0.10	----	0.15	0.05	----	----	----	0.05	0.15	Remainder
	5017	1986-08-18	USA	0.40	0.7	0.18-0.28	0.6-0.8	1.9-2.2	----	----	----	0.09	----	----	----	0.05	0.15	Remainder
	5018	1992-02-21	GERMANY	0.25	0.40	0.05	0.20-0.6	2.6-3.6	0.30	----	0.20	0.15	----	----	0.20-0.6 Mn+Cr[6]	0.05	0.15	Remainder
	5018A	1999-04-19	ROMANIA	0.40	0.40	0.10	0.35-0.50	3.0-3.6	0.30	----	0.20	0.15	----	----	0.35-0.7 Mn+Cr	0.05	0.15	Remainder
	5019[32]	1972-09-22	EAA	0.40	0.50	0.10	0.10-0.6	4.5-5.6	0.20	----	0.20	0.20	----	----	0.10-0.6 Mn+Cr	0.05	0.15	Remainder
	5019A	1998-11-25	USA	0.20	0.35	0.15	0.20-0.50	4.4-5.4	0.10	----	0.25	0.10	----	----	----	0.05	0.15	Remainder
	5119	1992-02-21	GERMANY	0.25	0.40	0.05	0.20-0.8	4.5-5.6	0.30	----	0.20	0.15	----	----	0.20-0.8 Mn+Cr[6]	0.05	0.15	Remainder
	5119A	2001-08-05	EAA	0.25	0.40	0.05	0.20-0.6	4.5-5.6	0.30	----	0.20	0.15	----	----	0.20-0.6 Mn+Cr[6,7]	0.05	0.15	Remainder
	5021	1993-06-25	NORWAY	0.40	0.50	0.15	0.10-0.50	2.2-2.8	0.15	----	0.15	----	----	----	----	0.05	0.15	Remainder
	5022	1995-09-08	JAPAN	0.25	0.40	0.20-0.50	0.20	3.5-4.9	0.10	----	0.25	0.10	----	----	----	0.05	0.15	Remainder
	5023	1995-09-08	JAPAN	0.25	0.40	0.20-0.50	0.20	5.0-6.2	0.10	----	0.25	0.10	----	----	----	0.05	0.15	Remainder
	5026	2001-02-19	GERMANY	0.55-1.4	0.20-1.0	0.10-0.8	0.6-1.8	3.9-4.9	0.30	----	1.0	0.20			0.30 Zr	0.05	0.15	Remainder
	5027	2002-01-28	GERMANY	0.05-0.20	0.20-0.40	0.05-0.15	0.40-0.8	4.7-5.4	0.10	----	0.25	0.15	----	----	----	0.05	0.15	Remainder
	5040	1961-02-24	USA	0.30	0.7	0.25	0.9-1.4	1.0-1.5	0.10-0.30	----	0.25	----	----	----	----	0.05	0.15	Remainder
+	5041	2005-06-28	JAPAN	0.40	0.40	0.10	0.30-1.0	3.0-4.0	0.50	----	0.10	0.20	----	----	----	0.05	0.15	Remainder
	5140	2001-05-14	USA	0.7	0.6	0.6	0.7-1.3	1.1-1.5	0.10	----	0.40	0.10	----	----	----	0.05	0.15	Remainder
	5042	1980-05-29	USA	0.20	0.35	0.15	0.20-0.50	3.0-4.0	0.10	----	0.25	0.10	----	----	----	0.05	0.15	Remainder
	5043	1982-01-11	USA	0.40	0.7	0.05-0.35	0.7-1.2	0.7-1.3	0.05	----	0.25	0.10	0.05	0.05	----	0.05	0.15	Remainder
	5049	1979-02-15	EAA	0.40	0.50	0.10	0.50-1.1	1.6-2.5	0.30	----	0.20	0.10	----	----	----	0.05	0.15	Remainder
	5149	1990-11-14	EAA	0.25	0.40	0.05	0.50-1.1	1.6-2.5	0.30	----	0.20	0.15	----	----	----	0.05	0.15	Remainder
‡	5249	1990-11-14	EAA	0.25	0.40	0.05	0.50-1.1	1.6-2.5	0.30	----	0.20	0.15	----	----	0.10-0.20 Zr[6]	0.05	0.15	Remainder
	5349	1992-05-01	USA	0.40	0.7	0.18-0.28	0.6-1.2	1.7-2.6	----	----	0.20	0.09	----	----	----	0.05	0.15	Remainder
	5449	1994-03-21	BELGIUM	0.40	0.7	0.30	0.6-1.1	1.6-2.6	0.30	----	0.30	0.10	----	----	----	0.05	0.15	Remainder
	5050	1954-07-01	USA	0.40	0.7	0.20	0.10	1.1-1.8	0.10	----	0.25	----	----	----	----	0.05	0.15	Remainder
	5050A	1973-04-27	AUSTRALIA	0.40	0.7	0.20	0.30	1.1-1.8	0.10	----	0.25	----	----	----	----	0.05	0.15	Remainder
	5150	1972-04-01	FRANCE	0.08	0.10	0.10	0.03	1.3-1.7	----	----	0.10	0.06	----	----	----	0.03	0.10	Remainder
	5051	1967-03-01	USA	0.40	0.7	0.25	0.20	1.7-2.2	0.10	----	0.25	0.10	----	----	----	0.05	0.15	Remainder
	5051A	1983-02-15	GERMANY	0.30	0.45	0.05	0.25	1.4-2.1	0.30	----	0.20	0.10	----	----	----	0.05	0.15	Remainder
	5151	1970-09-25	USA	0.20	0.35	0.15	0.10	1.5-2.1	0.10	----	0.15	0.10	----	----	----	0.05	0.15	Remainder
	5251	1972-09-22	EAA	0.40	0.50	0.15	0.10-0.50	1.7-2.4	0.15	----	0.15	0.15	----	----	----	0.05	0.15	Remainder
	5251A	1990-10-04	ARGENTINA	0.50	0.7	0.25	0.20-0.7	1.6-2.2	0.10	----	0.25	0.10	----	----	----	0.05	0.15	Remainder
	5351	1978-06-26	USA	0.08	0.10	0.10	0.10	1.6-2.2	----	----	0.05	----	----	0.05	----	0.03	0.10	Remainder
	5451	1981-07-22	USA	0.25	0.40	0.10	0.10	1.8-2.4	0.15-0.35	0.05	0.10	0.05	----	----	----	0.05	0.15	Remainder

See footnotes on pages 13-14.

CHEMICAL COMPOSITION LIMITS[1,2]

REGISTERED COMPOSITION–Continued

Only composition limits which are identical to those listed herein for a registered designation are applicable to that designation.

REGISTERED INTERNATIONAL DESIGNATION															OTHERS[39]		ALUMINUM
No.[11]	DATE	BY	Si	Fe	Cu	Mn	Mg	Cr	Ni	Zn	Ti	Ga	V		Each	Total[3]	Minimum
5052	1954-07-01	USA	0.25	0.40	0.10	0.10	2.2-2.8	0.15-0.35	----	0.10	----	----	----	----	0.05	0.15	Remainder
5252	1981-02-24	USA	0.08	0.10	0.10	0.10	2.2-2.8	----	----	0.05	----	----	0.05	----	0.03	0.10	Remainder
5352	1971-09-23	USA	0.45 Si + Fe		0.10	0.10	2.2-2.8	0.10	----	0.10	0.10	----	----	----	0.05	0.15	Remainder
5154[10]	1954-07-01	USA	0.25	0.40	0.10	0.10	3.1-3.9	0.15-0.35	----	0.20	0.20	----	----	6	0.05	0.15	Remainder
5154A	1972-06-23	UK	0.50	0.50	0.10	0.50	3.1-3.9	0.25	----	0.20	0.20	----	----	0.10-0.50 Mn+Cr[6]	0.05	0.15	Remainder
5154B	1978-11-15	ITALY	0.35	0.45	0.05	0.15-0.45	3.2-3.8	0.10	0.01	0.15	0.15	----	----	----	0.05	0.15	Remainder
5254	1954-07-01	USA	0.45 Si + Fe		0.05	0.01	3.1-3.9	0.15-0.35	----	0.20	0.05	----	----	----	0.05	0.15	Remainder
5354	1990-11-14	EAA	0.25	0.40	0.05	0.50-1.0	2.4-3.0	0.05-0.20	----	0.25	0.15	----	----	0.10-0.20 Zr	0.05	0.15	Remainder
5454	1957-07-08	USA	0.25	0.40	0.10	0.50-1.0	2.4-3.0	0.05-0.20	----	0.25	0.20	----	----	----	0.05	0.15	Remainder
5554	1958-03-05	USA	0.25	0.40	0.10	0.50-1.0	2.4-3.0	0.05-0.20	----	0.25	0.05-0.20	----	----	6	0.05	0.15	Remainder
5654	1968-05-29	USA	0.45 Si + Fe		0.05	0.01	3.1-3.9	0.15-0.35	----	0.20	0.05-0.15	----	----	6	0.05	0.15	Remainder
5654A	2001-08-05	EAA	0.45 Si + Fe		0.05	0.01	3.1-3.9	0.15-0.35	----	0.20	0.05-0.15	----	----	67	0.05	0.15	Remainder
5754	1970-06-30	USA	0.40	0.40	0.10	0.50	2.6-3.6	0.30	----	0.20	0.15	----	----	0.10-0.6 Mn+Cr	0.05	0.15	Remainder
5854	1988-11-29	USA	0.25	0.40	0.10	0.10	3.3-4.1	0.10	----	0.20	0.20	----	----	----	0.05	0.15	Remainder
5056	1954-07-01	USA	0.30	0.40	0.10	0.05-0.20	4.5-5.6	0.05-0.20	----	0.10	----	----	----	----	0.05	0.15	Remainder
5356	1954-07-01	USA	0.25	0.40	0.10	0.05-0.20	4.5-5.5	0.05-0.20	----	0.10	0.06-0.20	----	----	6	0.05	0.15	Remainder
5356A	2001-08-05	EAA	0.25	0.40	0.10	0.05-0.20	4.5-5.5	0.05-0.20	----	0.10	0.06-0.20	----	----	67	0.05	0.15	Remainder
5456	1956-10-04	USA	0.25	0.40	0.10	0.50-1.0	4.7-5.5	0.05-0.20	----	0.25	0.20	----	----	----	0.05	0.15	Remainder
5456A	1992-02-21	GERMANY	0.25	0.40	0.05	0.7-1.1	4.5-5.2	0.05-0.25	----	0.25	0.15	----	----	6	0.05	0.15	Remainder
5456B	2001-08-05	EAA	0.25	0.40	0.05	0.7-1.1	4.5-5.2	0.05-0.25	----	0.25	0.15	----	----	67	0.05	0.15	Remainder
5556	1956-10-08	USA	0.25	0.40	0.10	0.50-1.0	4.7-5.5	0.05-0.20	----	0.25	0.05-0.20	----	----	6	0.05	0.15	Remainder
5556A	1972-06-23	UK	0.25	0.40	0.10	0.6-1.0	5.0-5.5	0.05-0.20	----	0.20	0.05-0.20	----	----	6	0.05	0.15	Remainder
5556B	2001-08-05	EAA	0.25	0.40	0.10	0.6-1.0	5.0-5.5	0.05-0.20	----	0.20	0.05-0.20	----	----	67	0.05	0.15	Remainder
5556C	2001-11-15	FRANCE	0.25	0.40	0.10	0.50-1.0	4.7-5.5	0.05-0.20	----	0.25	0.05-0.20	----	----	67	0.05	0.15	Remainder
5257[10]	1961-03-27	USA	0.08	0.10	0.10	0.03	0.20-0.6	----	----	0.03	----	----	----	----	0.02	0.05	Remainder
5457	1957-12-24	USA	0.08	0.10	0.20	0.15-0.45	0.8-1.2	----	----	0.05	----	----	0.05	----	0.03	0.10	Remainder
5557	1977-07-21	USA	0.10	0.12	0.15	0.10-0.40	0.40-0.8	----	----	----	----	----	0.05	----	0.03	0.10	Remainder
5657	1960-02-26	USA	0.08	0.10	0.10	0.03	0.6-1.0	----	----	0.05	----	0.03	0.05	----	0.02	0.05	Remainder
5058	1991-07-15	GERMANY	0.40	0.50	0.10	0.20	4.5-5.6	0.10	----	0.20	0.20	----	----	57	0.05	0.15	Remainder
5059	1999-06-25	GERMANY	0.45	0.50	0.25	0.6-1.2	5.0-6.0	0.25	----	0.40-0.8	0.20	----	----	0.05-0.25 Zr	0.05	0.15	Remainder
5070	2003-01-31	BELGIUM	0.25	0.40	0.25	0.40-0.8	3.5-4.5	0.30	----	0.40-0.8	0.15	----	----	----	0.05	0.15	Remainder
5180	1963-10-22	USA	0.35 Si + Fe		0.10	0.20-0.7	3.5-4.5	0.10	----	1.7-2.8	0.06-0.20	----	----	0.08-0.25 Zr[6]	0.05	0.15	Remainder
5180A	2001-11-15	FRANCE	0.35 Si + Fe		0.10	0.20-0.7	3.5-4.5	0.10	----	1.7-2.8	0.06-0.20	----	----	0.08-0.25 Zr[67]	0.05	0.15	Remainder
5082	1963-08-14	USA	0.20	0.35	0.15	0.15	4.0-5.0	0.15	----	0.25	0.10	----	----	----	0.05	0.15	Remainder
5182	1967-11-10	USA	0.20	0.35	0.15	0.20-0.50	4.0-5.0	0.10	----	0.25	0.10	----	----	----	0.05	0.15	Remainder

See footnotes on pages 13-14.

CHEMICAL COMPOSITION LIMITS[1,2]

REGISTERED COMPOSITION–Continued

Only composition limits which are identical to those listed herein for a registered designation are applicable to that designation.

REGISTERED INTERNATIONAL DESIGNATION															OTHERS[38]		ALUMINUM
No.[75]	DATE	BY	Si	Fe	Cu	Mn	Mg	Cr	Ni	Zn	Ti	Ga	V		Each	Total[3]	Minimum
5083	1954-07-01	USA	0.40	0.40	0.10	0.40-1.0	4.0-4.9	0.05-0.25	---	0.25	0.15	---	---	---	0.05	0.15	Remainder
5183	1957-06-07	USA	0.40	0.40	0.10	0.50-1.0	4.3-5.2	0.05-0.25	---	0.25	0.15	---	---	6	0.05	0.15	Remainder
5183A	2001-08-05	EAA	0.40	0.40	0.10	0.50-1.0	4.3-5.2	0.05-0.25	---	0.25	0.15	---	---	67	0.05	0.15	Remainder
5283	1976-06-21	FRANCE	0.30	0.30	0.03	0.50-1.0	4.5-5.1	0.05	0.03	0.10	0.03	---	---	0.05 Zr	0.05	0.15	Remainder
5283A	1987-09-30	EAA	0.30	0.30	0.03	0.50-1.0	4.5-5.1	0.05	0.03	0.10	0.03	---	---	0.05 Zr[42]	0.05	0.15	Remainder
5283B	1999-05-04	USA	0.15	0.35	0.15	0.30-0.9	4.2-5.2	0.10	---	0.25	0.15	---	---	---	0.05	0.15	Remainder
5383	1995-06-26	FRANCE	0.25	0.25	0.20	0.7-1.0	4.0-5.2	0.25	---	0.40	0.15	---	---	0.20 Zr	0.05	0.15	Remainder
5483	2001-12-07	USA	0.30	0.25	0.10	0.7-1.0	4.3-5.2	0.15	---	0.40	0.15	---	---	0.05-0.20 Zr	0.05	0.15	Remainder
5086	1954-07-01	USA	0.40	0.50	0.10	0.20-0.7	3.5-4.5	0.05-0.25	---	0.25	0.15	---	---	---	0.05	0.15	Remainder
5186	1996-02-14	FRANCE	0.40	0.45	0.25	0.20-0.50	3.8-4.8	0.15	---	0.40	0.15	---	---	0.05 Zr	0.05	0.15	Remainder
‡ 5087	1990-11-14	EAA	0.25	0.40	0.05	0.7-1.1	4.5-5.2	0.05-0.25	---	0.25	0.15	---	---	0.10-0.20 Zr[6]	0.05	0.15	Remainder
5187	2001-08-05	EAA	0.25	0.40	0.05	0.7-1.1	4.5-5.2	0.05-0.25	---	0.25	0.15	---	---	0.10-0.20 Zr[47]	0.05	0.15	Remainder
5088	2002-07-15	FRANCE	0.20	0.10-0.35	0.25	0.20-0.50	4.7-5.5	0.15	---	0.20-0.40	---	---	---	0.15 Zr	0.05	0.15	Remainder
6101	1955-07-08	USA	0.30-0.7	0.50	0.10	0.03	0.35-0.8	0.03	---	0.10	---	---	---	0.06 B	0.03	0.10	Remainder
6101A	1974-02-05	UK	0.30-0.7	0.40	0.05	---	0.40-0.9	---	---	---	---	---	---	---	0.03	0.10	Remainder
6101B	1979-02-15	GERMANY	0.30-0.6	0.10-0.30	0.05	0.05	0.35-0.6	---	---	0.10	---	---	---	---	0.03	0.10	Remainder
6201	1960-09-07	USA	0.50-0.9	0.50	0.10	0.03	0.6-0.9	0.03	---	0.10	---	---	---	0.06 B	0.03	0.10	Remainder
6201A	1973-08-02	AUSTRALIA	0.50-0.7	0.50	0.04	---	0.6-0.9	---	---	---	---	---	---	0.06 B	0.03	0.10	Remainder
6401	1990-11-14	EAA	0.35-0.7	0.04	0.05-0.20	0.03	0.35-0.7	---	---	0.04	0.01	---	---	---	0.01	---	Remainder
+ 6501	2005-09-20	SWITZERLAND	0.20-0.6	0.35	0.20	0.05-0.20	0.20-0.6	0.05	---	0.15	0.15	---	---	---	0.05	0.15	Remainder
6002	1983-03-17	ITALY	0.6-0.9	0.25	0.10-0.25	0.10-0.20	0.45-0.7	0.05	---	---	0.08	---	---	0.09-0.14 Zr	0.05	0.15	Remainder
6003[88]	1954-07-01	USA	0.35-1.0	0.6	0.10	0.8	0.8-1.5	0.35	---	0.20	0.10	---	---	---	0.05	0.15	Remainder
6103	1984-12-20	AUSTRALIA	0.35-1.0	0.6	0.20-0.30	0.8	0.8-1.5	0.35	---	0.20	0.10	---	---	---	0.05	0.15	Remainder
6005	1962-12-20	USA	0.6-0.9	0.35	0.10	0.10	0.40-0.6	0.10	---	0.10	0.10	---	---	---	0.05	0.15	Remainder
6005A	1972-04-01	FRANCE	0.50-0.9	0.35	0.30	0.50	0.40-0.7	0.30	---	0.20	0.10	---	---	0.12-0.50 Mn+Cr	0.05	0.15	Remainder
6005B	1988-08-03	NETHERLANDS	0.45-0.8	0.30	0.10	0.10	0.40-0.8	0.10	---	0.10	0.10	---	---	---	0.05	0.15	Remainder
+ 6005C	2005-06-29	JAPAN	0.40-0.9	0.35	0.35	0.50	0.40-0.8	0.30	---	0.25	0.10	---	---	0.50 Mn+Cr	0.05	0.15	Remainder
6105	1965-11-23	USA	0.6-1.0	0.35	0.10	0.15	0.45-0.8	0.10	---	0.10	0.10	---	---	---	0.05	0.15	Remainder
6205	1970-03-19	USA	0.6-0.9	0.7	0.20	0.05-0.15	0.40-0.6	0.05-0.15	---	0.25	0.15	---	---	0.05-0.15 Zr	0.05	0.15	Remainder
6006	1971-10-20	USA	0.20-0.6	0.35	0.15-0.30	0.05-0.20	0.45-0.9	0.10	---	0.10	0.10	---	---	---	0.05	0.15	Remainder
6106	1979-04-23	FRANCE	0.30-0.6	0.35	0.25	0.05-0.20	0.40-0.8	0.20	---	0.10	---	---	---	---	0.05	0.10	Remainder
6206	1984-03-08	USA	0.35-0.7	0.35	0.20-0.50	0.13-0.30	0.45-0.8	0.10	---	0.20	0.10	---	---	---	0.05	0.15	Remainder
6306	1991-11-19	USA	0.20-0.6	0.10	0.05-0.18	0.10-0.40	0.45-0.9	---	---	0.05	0.05	---	---	---	0.05	0.15	Remainder
6008	1983-10-20	SWITZERLAND	0.50-0.9	0.35	0.30	0.30	0.40-0.7	0.30	---	0.20	0.10	---	0.05-0.20	---	0.05	0.15	Remainder
6009	1976-09-17	USA	0.6-1.0	0.50	0.15-0.6	0.20-0.8	0.40-0.8	0.10	---	0.25	0.10	---	---	---	0.05	0.15	Remainder
6010	1976-09-17	USA	0.8-1.2	0.50	0.15-0.6	0.20-0.8	0.6-1.0	0.10	---	0.25	0.10	---	---	---	0.05	0.15	Remainder
6110	1979-01-29	USA	0.7-1.5	0.8	0.20-0.7	0.20-0.7	0.50-1.1	0.04-0.25	---	0.30	0.15	---	---	---	0.05	0.15	Remainder
6110A	1996-07-28	GERMANY	0.7-1.1	0.50	0.30-0.8	0.30-0.9	0.7-1.1	0.05-0.25	---	0.20	---	---	---	0.20 Ti+Zr	0.05	0.15	Remainder

See footnotes on pages 13-14.

CHEMICAL COMPOSITION LIMITS[1,2]

REGISTERED COMPOSITION—Continued

Only composition limits which are identical to those listed herein for a registered designation are applicable to that designation.

REGISTERED INTERNATIONAL DESIGNATION															OTHERS[3]		ALUMINUM
No.[7]	DATE	BY	Si	Fe	Cu	Mn	Mg	Cr	Ni	Zn	Ti	Ga	V		Each	Total[3]	Minimum
6011	1954-07-01	USA	0.6-1.2	1.0	0.40-0.9	0.8	0.6-1.2	0.30	0.20	1.5	0.20	---	---	---	0.05	0.15	Remainder
6111	1982-10-07	USA	0.6-1.1	0.40	0.50-0.9	0.10-0.45	0.50-1.0	0.10	---	0.15	0.10	---	---	---	0.05	0.15	Remainder
6012	1979-02-15	GERMANY	0.6-1.4	0.50	0.10	0.40-1.0	0.6-1.2	0.30	---	0.30	0.20	---	---	0.7 Bi, 0.40-2.0 Pb	0.05	0.15	Remainder
6012A	1999-12-16	ITALY	0.6-1.4	0.50	0.40	0.20-1.0	0.6-1.2	0.30	---	0.30	0.20	---	---	0.7 Bi, 0.40-2.0 Sn	0.05	0.15	Remainder
6013	1983-03-15	USA	0.6-1.0	0.50	0.6-1.1	0.20-0.8	0.8-1.2	0.10	---	0.25	0.10	---	---	---	0.05	0.15	Remainder
6113	1991-09-13	USA	0.6-1.0	0.30	0.6-1.1	0.10-0.6	0.8-1.2	0.10	---	0.25	0.10	---	---	55	0.05	0.15	Remainder
6014	1983-01-20	SWITZERLAND	0.30-0.6	0.35	0.25	0.05-0.20	0.40-0.8	0.20	---	0.10	0.10	---	0.05-0.20	---	0.05	0.15	Remainder
6015	1984-09-01	ITALY	0.20-0.40	0.10-0.30	0.10-0.25	0.10	0.8-1.1	0.10	---	0.10	0.10	---	---	---	0.05	0.15	Remainder
6016	1984-09-17	SWITZERLAND	1.0-1.5	0.50	0.20	0.20	0.25-0.6	0.10	---	0.20	0.15	---	---	---	0.05	0.15	Remainder
6016A	1985-01-16	FRANCE	0.9-1.5	0.50	0.25	0.20	0.20-0.6	0.10	---	0.20	0.15	---	---	---	0.05	0.15	Remainder
6116	1996-06-26	SWITZERLAND	0.9-1.3	0.25	0.20	0.15	0.25-0.6	0.15	---	0.20	0.15	---	---	---	0.05	0.15	Remainder
6018	1991-06-17	SWITZERLAND	0.50-1.2	0.7	0.15-0.40	0.30-0.8	0.6-1.2	0.10	---	0.30	0.20	---	---	53	0.05	0.15	Remainder
6019	1996-10-17	USA	0.6-1.0	0.50	0.20-0.6	0.10	0.8-1.2	0.05-0.35	---	0.40-1.0	0.15	---	---	---	0.05	0.15	Remainder
6020	1995-08-25	USA	0.40-0.9	0.50	0.30-0.9	0.35	0.6-1.2	0.15	---	0.20	0.15	---	---	0.05 Pb, 0.9-1.5 Sn	0.05	0.15	Remainder
6021	2000-11-21	GERMANY	0.6-1.5	0.40	0.20	0.40-1.0	0.8-1.5	0.25	---	0.20	0.10	---	---	0.6-1.5 Sn	0.05	0.15	Remainder
6022	1995-08-23	USA	0.8-1.5	0.05-0.20	0.01-0.11	0.02-0.10	0.45-0.7	0.10	---	0.25	0.15	---	---	---	0.05	0.15	Remainder
6023	2001-08-05	SWITZERLAND	0.6-1.4	0.50	0.20-0.50	0.20-0.6	0.40-0.9	---	---	---	---	---	---	0.30-0.8 Bi, 0.6-1.2 Sn	0.05	0.15	Remainder
6024	2001-11-20	KOREA	0.7-1.3	0.05-0.7	0.30-0.9	0.30-1.2	0.30-1.0	0.20	---	0.20	0.20	---	---	---	0.05	0.15	Remainder
6025	2002-06-25	GERMANY	0.8-1.5	0.7	0.20-0.7	0.6-1.4	2.1-3.0	0.20	---	0.50	0.20	---	---	---	0.05	0.15	Remainder
6026	2004-06-25	ITALY	0.6-1.4	0.7	0.20-0.50	0.20-1.0	0.6-1.2	0.30	---	0.30	0.20	---	---	81	0.05	0.15	Remainder
6033	2002-08-26	USA	0.8-1.3	0.50	0.40-1.0	0.05	0.7-1.3	0.10	---	0.50-1.0	0.15	---	---	0.30-1.0 Bi, 0.05 Pb	0.05	0.15	Remainder
6040	2002-07-05	USA	0.40-0.8	0.7	0.20-0.8	0.15	0.8-1.2	0.15	---	0.25	0.15	---	---	72	0.05	0.15	Remainder
6151	1954-07-01	USA	0.6-1.2	1.0	0.35	0.20	0.45-0.8	0.15-0.35	---	0.25	0.15	---	---	---	0.05	0.15	Remainder
6351	1958-12-16	USA	0.7-1.3	0.50	0.10	0.40-0.8	0.40-0.8	---	---	0.20	0.20	---	---	---	0.05	0.15	Remainder
6351A	1988-12-22	FRANCE	0.7-1.3	0.50	0.10	0.40-0.8	0.40-0.8	---	---	0.20	0.20	---	---	42	0.05	0.15	Remainder
6451	2005-02-14	USA	0.6-1.0	0.40	0.40	0.05-0.40	0.40-0.8	0.10	---	0.15	---	---	0.10	---	0.05	0.15	Remainder
6951	1954-07-01	USA	0.20-0.50	0.8	0.15-0.40	0.10	0.40-0.8	---	---	0.20	---	---	---	---	0.05	0.15	Remainder
6053	1954-07-01	USA	11	0.35	0.10	---	1.1-1.4	0.15-0.35	---	0.10	---	---	---	---	0.05	0.15	Remainder
6056	1988-10-25	FRANCE	0.7-1.3	0.50	0.50-1.1	0.40-1.0	0.6-1.2	0.25	---	0.10-0.7	49	---	---	49	0.05	0.15	Remainder
6156	2003-02-19	FRANCE	0.7-1.3	0.20	0.7-1.1	0.40-0.7	0.6-1.2	0.25	---	0.10-0.7	---	---	---	---	0.05	0.15	Remainder
6060	1972-09-22	EAA	0.30-0.6	0.10-0.30	0.10	0.10	0.35-0.6	0.05	---	0.15	0.10	---	---	---	0.05	0.15	Remainder
6160	1993-07-30	USA	0.30-0.6	0.15	0.20	0.05	0.35-0.6	0.05	---	0.05	---	---	---	---	0.05	0.15	Remainder
6260	1996-11-05	USA	0.40-0.8	0.15-0.40	0.10	0.03	0.45-0.7	0.03	---	0.05	0.10	---	0.10-0.25	0.05 Zr	0.05	0.15	Remainder
6360	2001-11-08	USA	0.35-0.8	0.10-0.30	0.15	0.02-0.15	0.25-0.45	0.05	---	0.10	0.10	---	---	---	0.05	0.15	Remainder
6460	2001-10-29	USA	0.30-0.7	0.15	0.20	0.20	0.20-0.6	0.05	---	0.05	0.10	---	---	---	0.05	0.15	Remainder
6560	2001-10-29	USA	0.30-0.7	0.10-0.30	0.05-0.20	0.20	0.20-0.6	0.05	---	0.15	0.10	---	---	---	0.05	0.15	Remainder
6061	1954-07-01	USA	0.40-0.8	0.7	0.15-0.40	0.15	0.8-1.2	0.04-0.35	---	0.25	0.15	---	---	---	0.05	0.15	Remainder
6061A	1991-05-13	EAA	0.40-0.8	0.7	0.15-0.40	0.15	0.8-1.2	0.04-0.35	---	0.25	0.15	---	---	42	0.05	0.15	Remainder
6261	1968-04-23	USA	0.40-0.7	0.40	0.15-0.40	0.20-0.35	0.7-1.0	0.10	---	0.20	0.10	---	---	---	0.05	0.15	Remainder
6162	1959-03-26	USA	0.40-0.8	0.50	0.20	0.10	0.7-1.1	0.10	---	0.25	0.10	---	---	---	0.05	0.15	Remainder
6262	1960-01-14	USA	0.40-0.8	0.7	0.15-0.40	0.15	0.8-1.2	0.04-0.14	---	0.25	0.15	---	---	72	0.05	0.15	Remainder
6262A	2005-02-17	BELGIUM	0.40-0.8	0.7	0.15-0.40	0.15	0.8-1.2	0.04-0.14	---	0.25	0.10	---	---	42	0.05	0.15	Remainder

See footnotes on pages 13-14.

CHEMICAL COMPOSITION LIMITS[1,2]

REGISTERED COMPOSITION—Continued

Only composition limits which are identical to those listed herein for a registered designation are applicable to that designation.

	REGISTERED INTERNATIONAL DESIGNATION															OTHERS[39]		ALUMINUM
	No.[75]	DATE	BY	Si	Fe	Cu	Mn	Mg	Cr	Ni	Zn	Ti	Ga	V		Each	Total[3]	Minimum
	6063	1954-07-01	USA	0.20-0.6	0.35	0.10	0.10	0.45-0.9	0.10	...	0.10	0.10	...	...	...	0.05	0.15	Remainder
	6063A	1979-02-28	UK	0.30-0.6	0.15-0.35	0.10	0.15	0.6-0.9	0.05	...	0.15	0.10	...	...	...	0.05	0.15	Remainder
	6463	1957-04-15	USA	0.20-0.6	0.15	0.20	0.05	0.45-0.9	...	...	0.05	...	...	...	...	0.05	0.15	Remainder
	6463A	1973-08-02	AUSTRALIA	0.20-0.6	0.15	0.25	0.05	0.30-0.9	...	...	0.05	...	...	...	...	0.05	0.15	Remainder
	6763	1972-12-04	USA	0.20-0.6	0.08	0.04-0.16	0.03	0.45-0.9	...	...	0.03	...	...	0.05	...	0.03	0.10	Remainder
	6963	1994-08-23	USA	0.40-0.8	0.25	0.15-0.25	0.05	0.35-0.7	0.10	...	0.10	0.10	...	...	...	0.05	0.15	Remainder
+	6065	2005-02-17	BELGIUM	0.40-0.8	0.7	0.15-0.40	0.15	0.8-1.2	0.15	...	0.25	0.10	...	...	0.15 Zr[43]	0.05	0.15	Remainder
	6066	1954-07-01	USA	0.9-1.8	0.50	0.7-1.2	0.6-1.1	0.8-1.4	0.40	...	0.25	0.20	...	...	...	0.05	0.15	Remainder
	6069	1994-05-16	USA	0.6-1.2	0.40	0.55-1.0	0.05	1.2-1.6	0.05-0.30	...	0.05	0.10	...	0.10-0.30	0.05 Sr	0.05	0.15	Remainder
	6070	1962-01-18	USA	1.0-1.7	0.50	0.15-0.40	0.40-1.0	0.50-1.2	0.10	...	0.25	0.15	...	...	...	0.05	0.15	Remainder
	6081	1972-04-01	FRANCE	0.7-1.1	0.50	0.10	0.10-0.45	0.6-1.0	0.10	...	0.20	0.15	...	...	...	0.05	0.15	Remainder
	6181	1972-09-22	EAA	0.8-1.2	0.45	0.10	0.15	0.6-1.0	0.10	...	0.20	0.10	...	...	...	0.05	0.15	Remainder
	6181A	1997-07-31	SWITZERLAND	0.7-1.1	0.15-0.50	0.25	0.40	0.6-1.0	0.15	...	0.30	0.25	...	0.10	...	0.05	0.15	Remainder
	6082	1972-09-22	EAA	0.7-1.3	0.50	0.10	0.40-1.0	0.6-1.2	0.25	...	0.20	0.10	...	...	...	0.05	0.15	Remainder
+	6182	2005-02-17	BELGIUM	0.9-1.3	0.50	0.10	0.50-1.0	0.7-1.2	0.25	...	0.20	0.10	...	...	0.05-0.20 Zr,	0.05	0.15	Remainder
	6082A	1987-09-30	FRANCE	0.7-1.3	0.50	0.10	0.40-1.0	0.6-1.2	0.25	...	0.20	0.10	...	...	42	0.05	0.15	Remainder
	6091	1992-02-21	USA	0.40-0.8	0.7	0.15-0.40	0.15	0.8-1.2	0.15	...	0.25	0.15	...	...	55	0.05	0.15	Remainder
	6092	1992-02-21	USA	0.40-0.8	0.30	0.7-1.0	0.15	0.8-1.2	0.15	...	0.25	0.15	...	...	55	0.05	0.15	Remainder
	7003	1975-07-04	JAPAN	0.30	0.35	0.20	0.30	0.50-1.0	0.20	...	5.0-6.5	0.20	...	...	0.05-0.25 Zr	0.05	0.15	Remainder
	7004	1984-03-19	USA	0.25	0.35	0.05	0.20-0.7	1.0-2.0	0.05	...	3.8-4.6	0.05	...	...	0.10-0.20 Zr	0.05	0.15	Remainder
+	7204	2005-06-29	JAPAN	0.30	0.35	0.20	0.20-0.7	1.0-2.0	0.30	...	4.0-5.0	0.20	...	0.10	0.25 Zr	0.05	0.15	Remainder
	7005	1962-08-13	USA	0.35	0.40	0.10	0.20-0.7	1.0-1.8	0.06-0.20	...	4.0-5.0	0.01-0.06	...	...	0.08-0.20 Zr	0.05	0.15	Remainder
	7108[66]	1983-09-22	USA	0.10	0.10	0.05	0.05	0.7-1.4	...	...	4.5-5.5	0.05	...	...	0.12-0.25 Zr	0.05	0.15	Remainder
	7108A	1987-12-10	NORWAY	0.20	0.30	0.05	0.05	0.7-1.5	0.04	...	4.8-5.8	0.03	0.03	...	0.15-0.25 Zr	0.05	0.15	Remainder
	7009	1974-02-12	GERMANY	0.20	0.20	0.6-1.3	0.10	2.1-2.9	0.10-0.25	...	5.5-6.5	0.20	...	...	33	0.05	0.15	Remainder
	7010	1975-09-10	UK	0.12	0.15	1.5-2.0	0.10	2.1-2.6	0.05	0.05	5.7-6.7	0.06	...	...	0.10-0.16 Zr	0.05	0.15	Remainder
	7012	1975-01-12	ITALY	0.15	0.25	0.8-1.2	0.08-0.15	1.8-2.2	0.04	...	5.8-6.5	0.02-0.08	...	...	0.10-0.18 Zr	0.05	0.15	Remainder
	7014	1977-06-30	UK	0.50	0.50	0.30-0.7	0.30-0.7	2.2-3.2	...	0.10	5.2-6.2	...	...	...	0.20 Ti+Zr	0.05	0.15	Remainder
	7015	1977-09-16	SPAIN	0.20	0.30	0.06-0.15	0.10	1.3-2.1	0.15	...	4.6-5.2	0.10	...	...	0.10-0.20 Zr	0.05	0.15	Remainder
	7016	1972-06-29	USA	0.10	0.12	0.45-1.0	0.03	0.8-1.4	...	...	4.0-5.0	0.03	...	0.05	...	0.03	0.10	Remainder
	7116	1975-06-12	USA	0.15	0.30	0.50-1.1	0.05	0.8-1.4	...	...	4.2-5.2	0.05	0.03	0.05	...	0.05	0.15	Remainder
	7017	1978-03-23	UK	0.35	0.45	0.20	0.05-0.50	2.0-3.0	0.35	0.10	4.0-5.2	0.15	...	...	0.10-0.25 Zr[24]	0.05	0.15	Remainder
	7018	1978-03-23	UK	0.35	0.45	0.20	0.15-0.50	0.7-1.5	0.20	0.10	4.5-5.5	0.15	...	...	0.10-0.25 Zr	0.05	0.15	Remainder
	7019	1978-03-23	UK	0.35	0.45	0.20	0.15-0.50	1.5-2.5	0.20	0.10	3.5-4.5	0.15	...	...	0.10-0.25 Zr	0.05	0.15	Remainder
	7019A	1983-01-10	ARGENTINA	0.30	0.40	0.10	0.10-0.6	1.5-2.5	0.05-0.35	...	3.0-5.0	0.10	...	...	...	0.05	0.15	Remainder
	7020	1972-09-22	EAA	0.35	0.40	0.20	0.05-0.50	1.0-1.4	0.10-0.35	...	4.0-5.0	...	...	...	22	0.05	0.15	Remainder
	7021	1976-11-10	USA	0.25	0.40	0.25	0.10	1.2-1.8	0.05	...	5.0-6.0	0.10	...	...	0.08-0.18 Zr	0.05	0.15	Remainder
	7022	1979-02-15	EAA	0.50	0.50	0.50-1.0	0.10-0.40	2.6-3.7	0.10-0.30	...	4.3-5.2	...	...	...	0.20 Ti+Zr	0.05	0.15	Remainder
	7122	2000-02-24	SWITZERLAND	0.25	0.35	0.50-1.0	0.10	2.6-3.7	0.10	...	4.3-5.2	0.15	...	...	0.10-0.25 Zr	0.05	0.15	Remainder
	7023	1983-01-10	ARGENTINA	0.50	0.50	0.50-1.0	0.10-0.6	2.0-3.0	0.05-0.35	...	4.0-6.0	0.10	...	...	...	0.05	0.15	Remainder
	7024	1983-01-10	ARGENTINA	0.30	0.40	0.10	0.10-0.6	0.50-1.0	0.05-0.35	...	3.0-5.0	0.10	...	...	...	0.05	0.15	Remainder
	7025	1983-01-10	ARGENTINA	0.30	0.40	0.10	0.10-0.6	0.8-1.5	0.05-0.35	...	3.0-5.0	0.10	...	...	...	0.05	0.15	Remainder

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CHEMICAL COMPOSITION LIMITS[1,2]

REGISTERED COMPOSITION—Continued

Only composition limits which are identical to those listed herein for a registered designation are applicable to that designation.

REGISTERED INTERNATIONAL DESIGNATION															OTHERS[30]		ALUMINUM
No.[75]	DATE	BY	Si	Fe	Cu	Mn	Mg	Cr	Ni	Zn	Ti	Ga	V		Each	Total[3]	Minimum
7026	1983-03-17	ITALY	0.08	0.12	0.6-0.9	0.05-0.20	1.5-1.9	...	...	4.6-5.2	0.05	...	...	0.09-0.14 Zr	0.03	0.10	Remainder
7028	1987-05-11	SPAIN	0.35	0.50	0.10-0.30	0.15-0.6	1.5-2.3	0.20	...	4.5-5.2	0.05	...	...	0.08-0.25 Zr+Ti	0.05	0.15	Remainder
7029	1975-12-08	USA	0.10	0.12	0.50-0.9	0.03	1.3-2.0	...	...	4.2-5.2	0.05	...	0.05	...	0.03	0.10	Remainder
7129	1977-01-06	USA	0.15	0.30	0.50-0.9	0.10	1.3-2.0	0.10	...	4.2-5.2	0.05	0.03	0.05	...	0.05	0.15	Remainder
7229	1988-02-25	USA	0.06	0.08	0.50-0.9	0.03	1.3-2.0	...	...	4.2-5.2	0.05	...	0.05	...	0.03	0.10	Remainder
7030	1987-12-10	NORWAY	0.20	0.30	0.20-0.40	0.05	1.0-1.5	0.04	...	4.8-5.9	0.03	0.03	...	0.03 Zr	0.05	0.15	Remainder
7031	1988-11-14	USA	0.30	0.8-1.4	0.10	0.10-0.40	0.10	...	...	0.8-1.8	...	...	...	...	0.05	0.15	Remainder
7032	1995-11-20	USA	0.10	0.12	1.7-2.3	0.05	1.5-2.5	0.15-0.25		5.5-6.5	0.10	...	...	0.01 Bi, 0.01 Pb	0.05	0.15	Remainder
7033	1996-08-29	USA	0.15	0.30	0.7-1.3	0.10	1.3-2.2	0.20	...	4.6-5.6	0.10	0.03	0.05	0.08-0.15 Zr	0.05	0.15	Remainder
7034	1999-04-08	UK	0.10	0.12	0.8-1.2	0.25	2.0-3.0	0.20	...	11.0-12.0	...	...	...	0.08-0.30 Zr	0.05	0.15	Remainder
7035	2003-04-28	SWITZERLAND	0.15	0.25	0.05-0.30	0.10	2.5-3.5	0.05	...	4.3-5.5	0.02-0.05	...	...	0.08-0.20 Zr	0.05	0.15	Remainder
+ 7036	2004-04-20	USA	0.12	0.15	1.9-2.5	0.05	1.8-2.5	0.08-0.13	...	8.4-9.4	0.10	...	...	0.10-0.20 Zr	0.05	0.15	Remainder
+ 7136	2004-09-08	USA	0.12	0.15	1.9-2.5	0.05	1.8-2.5	0.05	...	8.4-9.4	0.10	...	...	0.10-0.20 Zr	0.05	0.15	Remainder
7039	1962-07-16	USA	0.30	0.40	0.10	0.10-0.40	2.3-3.3	0.15-0.25	...	3.5-4.5	0.10	...	...	...	0.05	0.15	Remainder
7040	1996-02-14	FRANCE	0.10	0.13	1.5-2.3	0.04	1.7-2.4	0.04	...	5.7-6.7	0.06	...	...	0.05-0.12 Zr	0.05	0.15	Remainder
+ 7140	2005-04-07	FRANCE	0.10	0.13	1.3-2.3	0.04	1.5-2.4	0.04	...	6.2-7.0	0.06	...	...	0.05-0.12	0.05	0.15	Remainder
7046	1973-05-16	USA	0.20	0.40	0.25	0.30	1.0-1.6	0.20	...	6.6-7.6	0.06	...	...	0.10-0.18 Zr	0.05	0.15	Remainder
7046A	1999-02-24	NORWAY	0.20	0.40	0.35	0.30	0.8-1.6	0.20	...	6.1-7.3	0.06	...	...	0.10-0.25 Zr	0.05	0.15	Remainder
7049	1968-05-10	USA	0.25	0.35	1.2-1.9	0.20	2.0-2.9	0.10-0.22	...	7.2-8.2	0.10	...	...	...	0.05	0.15	Remainder
7049A	1972-04-01	FRANCE	0.40	0.50	1.2-1.9	0.50	2.1-3.1	0.05-0.25	...	7.2-8.4	...	...	...	0.25 Zr+Ti	0.05	0.15	Remainder
7149	1975-10-28	USA	0.15	0.20	1.2-1.9	0.20	2.0-2.9	0.10-0.22	...	7.2-8.2	0.10	...	...	...	0.05	0.15	Remainder
7249	1992-12-11	USA	0.10	0.12	1.3-1.9	0.10	2.0-2.4	0.12-0.18	...	7.5-8.2	0.06	...	...	...	0.05	0.15	Remainder
7349	1994-01-04	FRANCE	0.12	0.15	1.4-2.1	0.20	1.8-2.7	0.10-0.22	...	7.5-8.7	...	...	...	0.25 Ti+Zr	0.05	0.15	Remainder
7449	1994-01-04	FRANCE	0.12	0.15	1.4-2.1	0.20	1.8-2.7	...	...	7.5-8.7	...	...	...	0.25 Ti+Zr	0.05	0.15	Remainder
7050	1971-02-01	USA	0.12	0.15	2.0-2.6	0.10	1.9-2.6	0.04	...	5.7-6.7	0.06	...	...	0.08-0.15 Zr	0.05	0.15	Remainder
7050A	1996-02-14	FRANCE	0.12	0.15	1.7-2.4	0.04	1.7-2.6	0.04	0.03	5.7-6.9	0.06			0.05-0.12 Zr	0.05	0.15	Remainder
7150	1978-05-04	USA	0.12	0.15	1.9-2.5	0.10	2.0-2.7	0.04	...	5.9-6.9	0.06	...	...	0.08-0.15 Zr	0.05	0.15	Remainder
7250	2001-01-24	USA	0.08	0.10	2.0-2.4	0.10	1.9-2.3	0.04	...	5.7-6.5	0.06	...	...	0.08-0.13 Zr	0.05	0.15	Remainder
7055	1991-02-13	USA	0.10	0.15	2.0-2.6	0.05	1.8-2.3	0.04	...	7.6-8.4	0.06	...	...	0.08-0.25 Zr	0.05	0.15	Remainder
+ 7056	2004-08-17	FRANCE	0.10	0.12	1.2-1.9	0.20	1.5-2.3	...	...	8.5-9.7	0.08	...	...	0.05-0.15 Zr	0.05	0.15	Remainder
7060	1986-12-23	FRANCE	0.15	0.20	1.8-2.6	0.20	1.3-2.1	0.15-0.25	...	6.1-7.5	0.05	...	...	0.003 Pb, 0.05 Zr	0.05	0.15	Remainder
7064	1985-01-09	USA	0.12	0.15	1.8-2.4	...	1.9-2.9	0.06-0.25	...	6.8-8.0	...	...	...	0.10-0.50 Zr[34]	0.05	0.15	Remainder
7068	1996-10-30	USA	0.12	0.15	1.6-2.4	0.10	2.2-3.0	0.05	...	7.3-8.3	0.10	...	...	0.05-0.15 Zr	0.05	0.15	Remainder
7168	2002-05-16	USA	0.10	0.12	1.6-2.4	0.05	2.0-2.6	0.04	...	7.8-8.8	0.10	...	...	0.05-0.15 Zr	0.05	0.15	Remainder
7072[66]	1954-07-01	USA	0.7 Si + Fe		0.10	0.10	0.10	...	...	0.8-1.3	...	...	...	...	0.05	0.15	Remainder
7075	1954-07-01	USA	0.40	0.50	1.2-2.0	0.30	2.1-2.9	0.18-0.28	...	5.1-6.1	0.20	...	...	16	0.05	0.15	Remainder
7175	1957-11-08	USA	0.15	0.20	1.2-2.0	0.10	2.1-2.9	0.18-0.28	...	5.1-6.1	0.10	...	...	...	0.05	0.15	Remainder
7475	1969-09-15	USA	0.10	0.12	1.2-1.9	0.06	1.9-2.6	0.18-0.25	...	5.2-6.2	0.06	...	...	...	0.05	0.15	Remainder
7076	1954-07-01	USA	0.40	0.6	0.30-1.0	0.30-0.8	1.2-2.0	...	...	7.0-8.0	0.20	...	...	...	0.05	0.15	Remainder
7178[10]	1954-07-01	USA	0.40	0.50	1.6-2.4	0.30	2.4-3.1	0.18-0.28	...	6.3-7.3	0.20	...	...	...	0.05	0.15	Remainder
7278	1981-05-26	NORWAY	0.15	0.20	1.6-2.2	0.02	2.5-3.2	0.17-0.25	...	6.6-7.4	0.03	0.03	0.05	...	0.03	0.10	Remainder
7278A	1991-06-17	SWITZERLAND	0.12	0.15	1.3-2.1	0.25	2.3-3.2	0.05	...	6.4-7.4	0.05	...	...	0.05-0.25 Zr	0.05	0.15	Remainder

See footnotes on pages 13-14.

CHEMICAL COMPOSITION LIMITS[1,2]
REGISTERED COMPOSITION–Continued

Only composition limits which are identical to those listed herein for a registered designation are applicable to that designation.

REGISTERED INTERNATIONAL DESIGNATION															OTHERS[38]		ALUMINUM
No.[75]	DATE	BY	Si	Fe	Cu	Mn	Mg	Cr	Ni	Zn	Ti	Ga	V		Each	Total[3]	Minimum
* 7081	2005-05-17	GERMANY	0.12	0.15	1.2-1.8	0.25	1.8-2.2	0.04	...	6.9-7.5	0.06	...	...	0.06-0.15 Zr	0.05	0.15	Remainder
7085	2002-02-15	USA	0.06	0.08	1.3-2.0	0.04	1.2-1.8	0.04	...	7.0-8.0	0.06	...	...	0.08-0.15 Zr	0.05	0.15	Remainder
7090	1980-07-29	USA	0.12	0.15	0.6-1.3	...	2.0-3.0	...	...	7.3-8.7	...	...	...	1.0-1.9 Co[31]	0.05	0.15	Remainder
7093	1990-04-11	USA	0.12	0.15	1.1-1.9	...	2.0-3.0	...	0.04-0.16	8.3-9.7	...	...	...	0.08-0.20 Zr[55]	0.05	0.15	Remainder
* 7095	2005-06-16	USA	0.10	0.12	2.0-2.8	0.05	1.4-2.0	...	...	8.6-9.8	0.06	...	...	0.08-0.15 Zr	0.05	0.15	Remainder
8005	1976-12-01	ITALY	0.20-0.50	0.40-0.8	0.05	...	0.05	...	...	0.05	...	...	...	...	0.05	0.15	Remainder
8006	1978-06-16	USA	0.40	1.2-2.0	0.30	0.30-1.0	0.10	...	...	0.10	...	...	...	...	0.05	0.15	Remainder
8007	1978-06-16	USA	0.40	1.2-2.0	0.10	0.30-1.0	0.10	...	...	0.8-1.8	...	...	...	...	0.05	0.15	Remainder
8008	1979-03-08	SPAIN	0.6	0.9-1.6	0.20	0.50-1.0	...	...	...	0.10	0.10	...	...	...	0.05	0.15	Remainder
8010	1988-06-17	USA	0.40	0.35-0.7	0.10-0.30	0.10-0.8	0.10-0.50	0.20	...	0.40	0.10	...	...	...	0.05	0.15	Remainder
8011[10]	1970-06-30	USA	0.50-0.9	0.6-1.0	0.10	0.20	0.05	0.05	...	0.10	0.08	...	...	...	0.05	0.15	Remainder
8011A	1979-02-15	GERMANY	0.40-0.8	0.50-1.0	0.10	0.10	0.10	0.10	...	0.10	0.05	...	...	...	0.05	0.15	Remainder
8111	1979-11-14	USA	0.30-1.1	0.40-1.0	0.10	0.10	0.05	0.05	...	0.10	0.08	...	...	...	0.05	0.15	Remainder
8211	1990-03-13	NETHERLANDS	0.40-0.8	0.50-1.0	0.10	0.05-0.20	0.10	0.15	...	0.10	0.05	...	...	...	0.05	0.15	Remainder
8112[10]	1954-07-01	USA	1.0	1.0	0.40	0.6	0.7	0.20	...	1.0	0.20	...	...	...	0.05	0.15	Remainder
8014	1983-10-13	USA	0.30	1.2-1.6	0.20	0.20-0.6	0.10	...	...	0.10	0.10	...	...	...	0.05	0.15	Remainder
8015	1988-11-14	USA	0.30	0.8-1.4	0.10	0.10-0.40	0.10	...	...	0.10	...	...	...	...	0.05	0.15	Remainder
8016	1989-03-30	NORWAY	0.20	0.7-1.1	0.10	0.10-0.30	0.10	...	...	0.10	...	...	...	...	0.05	0.15	Remainder
8017	1983-10-04	USA	0.10	0.55-0.8	0.10-0.20	...	0.01-0.05	...	...	0.05	...	...	...	0.04 B, 0.003 Li	0.03	0.10	Remainder
8018	1989-06-21	UK	0.50-0.9	0.6-1.0	0.30-0.6	0.30	...	...	...	...	0.006-0.06	...	...	...	0.05	0.15	Remainder
8019	1990-04-11	USA	0.20	7.3-8.3	...	0.05	...	...	...	0.05	0.05	...	...	[51]	0.05	0.15	Remainder
8021	1982-01-24	JAPAN	0.15	1.2-1.7	0.05	...	...	...	...	...	...	...	...	...	0.05	0.15	Remainder
8021A	1992-05-18	UK	0.20	1.2-1.7	0.05	0.03	0.02	...	...	0.05	0.05	...	...	...	0.02	0.15	Remainder
8021B	1996-08-09	EAA	0.40	1.1-1.7	0.05	0.03	0.01	0.03	...	0.05	0.05	...	...	...	0.03	0.10	Remainder
8022	1991-08-28	USA	1.2-1.4	6.2-6.8	...	0.10	...	0.10	...	0.25	0.10	...	0.40-0.8	[54]	0.05	0.15	Remainder
8023	1997-04-16	BRAZIL	0.20	1.3-1.6	0.10-0.40	0.30-0.6	0.005	0.02	...	...	0.05-0.10	...	...	0.01-0.02 B	0.05	0.15	Remainder
8024	1999-04-09	UK	0.10	0.12	...	...	...	...	...	...	...	...	...	3.4-4.2 Li, 0.08-0.25 Zr	0.05	0.15	Remainder
8025	2000-09-15	SKANALUMINUM	0.05-0.15	0.06-0.25	0.20	0.03-0.10	0.05	0.18	...	0.50	0.005-0.02	...	...	0.02-0.20 Zr	0.05	0.15	Remainder
8030	1975-09-29	USA	0.10	0.30-0.8	0.15-0.30	...	0.05	...	...	0.05	...	...	...	0.001-0.04 B	0.03	0.10	Remainder
8130	1976-03-13	USA	0.15[15]	0.40-1.0[15]	0.05-0.15	...	...	...	...	0.10	...	...	...	...	0.03	0.10	Remainder
8040	1982-11-15	USA	1.0 Si + Fe		0.20	0.05	...	...	...	0.20	...	...	...	0.10-0.30 Zr	0.05	0.15	Remainder
8050	1988-11-11	EAA	0.15-0.30	1.1-1.2	0.05	0.45-0.55	0.05	0.05	...	0.10	...	...	...	...	0.05	0.15	Remainder
8150	1998-04-09	AUSTRALIA	0.30	0.9-1.3	...	0.20-0.7	...	...	...	...	0.05	...	...	...	0.05	0.15	Remainder
* 8076A	2005-07-05	GERMANY	0.10	0.40-0.8	0.04	0.02	0.08-0.25	0.02	...	0.05	0.02	...	...	...	0.03	0.10	Remainder
8176	1976-01-21	USA	0.03-0.15	0.40-1.0	...	...	...	...	...	0.10	...	0.03	...	...	0.05	0.15	Remainder
8077	1975-05-20	USA	0.10	0.10-0.40	0.05	...	0.10-0.30	...	...	0.05	...	...	...	0.05 B[17]	0.03	0.10	Remainder
8079	1989-10-09	USA	0.05-0.30	0.7-1.3	0.05	...	...	...	...	0.10	...	...	...	...	0.05	0.15	Remainder
8090	1984-07-16	EAA	0.20	0.30	1.0-1.6	0.10	0.6-1.3	0.10	...	0.25	0.10	...	...	0.04-0.16 Zr[33]	0.05	0.15	Remainder
8091	1985-03-29	UK	0.30	0.50	1.6-2.2	0.10	0.50-1.2	0.10	...	0.25	0.10	...	...	0.08-0.16 Zr[36]	0.05	0.15	Remainder
8093	1990-02-01	FRANCE	0.10	0.10	1.0-1.6	0.10	0.9-1.6	0.10	...	0.25	0.10	...	...	0.04-0.14 Zr[30]	0.05	0.15	Remainder

See footnotes on pages 13-14.

FOOTNOTES

1. Composition in weight percent maximum unless shown as a range or a minimum. Standard limits for alloying elements and impurities are expressed to the following places:

Less than 0.001 percent	0.000X
0.001 but less than 0.01	0.00X
0.01 but less than 0.10 percent	
Unalloyed aluminum made by a refining process	0.0XX
Alloys and unalloyed aluminum not made by a refining process	0.0X
0.10 through 0.55 percent	0.XX
(It is customary to express limits of 0.30 percent through 0.55 percent as 0.X0 or 0.X5).	
Over 0.55 percent	0.X, X.X, etc.
(except that combined Si + Fe limits for 1xxx designations must be expressed as 0.XX or 1.XX).	

2. Except for "Aluminum" and "Others," analysis normally is made for elements for which specific limits are shown. For purposes of determining conformance to these limits, an observed value or calculated value obtained from analysis is rounded off to the nearest unit in the last right hand place of figures used in expressing the specified limit, in accordance with the following:

   When the figure next beyond the last figure or place to be retained is less than 5, the figure in the last place retained should be kept unchanged.

   When the figure next beyond the last figure or place to be retained is greater than 5, the figure in the last place retained should be increased by 1.

   When the figure next beyond the last figure or place to be retained is 5 and

   (1) there are no figures or only zeros beyond this 5, if the figure in the last place to be retained is odd, it should be increased by 1; if even, it should be kept unchanged;

   (2) if the 5 next beyond the figure in the last place to be retained is followed by any figures other than zero, the figure in the last place retained should be increased by 1, whether odd or even.

3. The sum of those "Others" metallic elements 0.010 or more each, expressed to the second decimal before determining the sum.

4. The aluminum content for unalloyed aluminum not made by a refining process is the difference between 100.00 percent and the sum of all other analyzed metallic elements present in amounts of 0.010 percent or more each, expressed to the second decimal before determining the sum. For alloys and unalloyed aluminum not made by a refining process, when the specified maximum limit is 0.XX, an observed value or a calculated value greater than 0.005 but less than 0.010% is rounded off and shown as "less than 0.01".

5. The aluminum content for unalloyed aluminum made by a refining process is the difference between 100.00 percent and the sum of all other metallic elements present in amounts of 0.0010 percent or more each, expressed to the third decimal before determining the sum, which is rounded to the second decimal before subtracting. When an element's specified maximum limit is 0.0XX, an observed value or a calculated value greater than 0.0005 but less than 0.0010% is rounded off and shown as "less than 0.001".

6. 0.0003 max Be for welding electrode, welding rod and filler wire.

7. 0.14 max Si + Fe.

8. 0.20-0.6 Bi, 0.20-0.6 Pb.

9. A Zr + Ti limit of 0.20 percent maximum may be used with this alloy designation for extruded and forged products only, but only when the supplier or producer and the purchaser have mutually so agreed. Agreement may be indicated, for example, by reference to a standard, by letter, by order note, or other means which allow the Zr + Ti limit.

10. This designation is considered the sole original alloy for this alloy family.

11. 45-65% of Mg.

12. 0.40-0.7 Bi, 0.40-0.7 Pb.

13. 0.001 max B, 0.003 max Cd, 0.001 max Co, 0.008 max Li.

14. 0.10-0.50 Bi, 0.10-0.25 Sn.

15. 1.0 max Si + Fe.

16. A Zr + Ti limit of 0.25 percent maximum may be used with this alloy designation for extruded and forged products only, but only when the supplier or producer and the purchaser have mutually so agreed. Agreement may be indicated, for example, by reference to a standard, by letter, by order note, or other means which allow the Zr + Ti limit.

17. 0.02-0.08 Zr.

18. Formerly designated EC.

19. Inactive alloys can be reactivated with their original designation and original chemical composition limits. When possible, the original chemical composition limits shall be restored. An inactive experimental alloy can only be reactivated if the "X" is dropped. Inactive designations may be eligible for reassignment for registration of new compositions only if:
   (a) All available designations in this alloy family have been exhausted.
   (b) Ten (10) years have passed from the date of deactivation.
   (c) The alloy is not an "original" alloy. (Note: An inactive "original" alloy may be eligible for registration of new compositions with different limits if it has neither active nor inactive modification nor national variations assigned.)

20. 0.50 max Si + Fe + Cu.

21. 0.05-0.50 Ag.

22. 0.08-0.20 Zr, 0.08-0.25 Zr + Ti.

23. 0.25-0.40 Ag.

24. 0.15 min Mn + Cr.

25. 0.05-0.20 Cd.

26. 0.20 max Bi, 0.8-1.5 Pb, 0.20 max Sn.

27. 0.25-0.6 Ag, 1.4-2.1 Li.

28. 0.40 max Si + Fe.

29. 0.05-0.20 Cd, 0.03-0.08 Sn.

30. 1.9-2.6 Li.

31. 0.20-0.50 Oxygen.

32. 0.0008 max Be, 0.05-0.55 Sc

33. 2.2-2.7 Li.

34. 0.10-0.40 Co, 0.05-0.30 Oxygen.

35. 1.7-2.3 Li.

36. 2.4-2.8 Li.

37. 0.05-0.50 In, 0.05-0.50 Sn

38. 0.25-0.6 Ag, 0.8-1.3 Li.

39. "Others" includes listed elements for which no specific limit is shown as well as unlisted metallic elements. The producer may analyze samples for trace elements not specified in the registration or specification. However, such analysis is not required and may not cover all metallic "other" elements. Should any analysis by the producer or the purchaser establish that an "others" element exceeds the limit of "Each" or that the aggregate of several "others" elements exceeds the limit of "Total", the material shall be considered non-conforming.

40. 0.02 max B.

41. 0.01 max B.

42. 0.003 max Pb.

43. 0.6-1.5 Bi, 0.05 max Cd.

FOOTNOTES – Continued

44. 0.6 max Oxygen.
45. 0.005 max Be, 0.05-0.50 Oxygen.
46. 0.25-0.6 Ag, 0.7-1.4 Li.
47. 0.25-0.6 Ag, 0.7-1.5 Li.
48. 1.6-2.0 Li, 0.05-0.12 Zr, 0.0001 Be
49. 0.20 max Zr + Ti.
50. 0.30 max Oxygen.
51. 3.5-4.5 Ce, 0.05-0.50 Oxygen.
52. Alloy 5056A redesignated 5019.
53. 0.40-0.7 Bi, 0.40-1.2 Pb.
54. 0.05-0.20 Oxygen.
55. 0.05-0.50 Oxygen.
56. 1.0-1.3 Carbon, 1.2-1.4 Li, 0.20-0.7 Oxygen.
57. 1.2-1.8 Pb.
58. 0.01-0.06 Sc
59. 0.25-0.6 Ag, 0.8-1.2 Li.
60. 0.25-0.6 Ag, 1.3-1.9 Li.
61. 1.2-1.8 Li.
62. 1.3-1.7 Li.
63. 0.20-0.7 Bi, 0.20-0.6 Sn.
64. 0.20-0.6 Bi, 0.10-0.50 Sn.
65. 1.1-1.7 Li.
66. Cladding is a main use.
67. 0.0005 max Be for welding electrode, welding rod and filler wire.
68. 0.20 max Bi, 0.05 max Pb, 0.8-1.5 Sn.
69. 0.20-0.6 Bi, 0.05 max Pb, 0.20-0.6 Sn.
70. 0.30-0.6 Bi, 0.30-0.7 Sn.
71. 0.40 Bi, 0.20 Pb, 0.7-1.5 Sn.
72. 0.15-0.7 Bi, 0.30-1.2 Sn.
73. 0.10-0.25 Zr, 0.30-0.7 Ag.
74. 0.40-0.7 Ag, 0.08-0.15 Zr, 0.0001 Be
75. Various organizations include a prefix to these registered designations that do not change the registered composition and should be considered equivalent to those listed in this document. Examples of such equivalent designations are the AW-xxxx used in European EN standards and the A9xxxx designations used in the Unified Numbering System.
76. 0.10-1.0 Bi, 1.0 Pb, 0.10-1.0 Sn
77. 0.15-0.6 Ag
78. 0.20-0.7 Ag, 0.7-1.3 Li
79. 0.0001 Be, 1.4-1.8 Li
80. 0.005 B, 0.005 Na, 0.005 P
81. 0.50-1.5 Bi, 0.40 Pb, 0.05 Sn
82. 0.40-0.9 Bi, 0.40-1.0 Sn
83. 0.50-1.5 Bi, 0.05 Pb
84. 0.10-0.50 Ag, 0.8-1.1 Li

\+ Designation added since previous issue.
++ Composition limits revised since previous issue.
* "X" removed from designation since previous issue.

CALCULATED NOMINAL DENSITIES FOR ACTIVE WROUGHT ALUMINUM AND WROUGHT ALUMINUM ALLOYS

Density is dependent upon composition and is determined by computation rather than by a weighing method. The values shown below have been computed in accordance with the Aluminum and Aluminum Alloy Density Calculation Procedure appearing on pages 2-12 and 2-13 of Aluminum Standards and Data. These calculated densities are nominal values and should not be specified as engineering requirements but may be used in calculating nominal values for weight per unit length, weight per unit area, covering area, etc.

Limiting the expression of nominal density to the number of decimal places indicated is based on the fact that composition variations are discernible from one cast to another for most alloys. The expression of nominal density to more decimal places than allowed by the following implies higher precision than is justified and should not be used.

1. Alloys listed below which have a minimum aluminum content of 99.35% or greater have nominal density values which are rounded in the US customary system (lbs/in^3) to the nearest multiple of 0.0005 and in the metric system [(kg/m^3) x 10^3] to the nearest multiple of 0.005.

2. Alloys listed below which have a minimum aluminum content of less than 99.35% have nominal density values which are rounded in the US customary system (lbs/in^3) to the nearest multiple of 0.001 and in the metric system [(kg/m^3) x 10^3] to the nearest multiple of 0.01.

The US customary (lbs/in^3) unit values are derived from metric values and subsequently rounded and are not to be back-converted to metric values.

		Density				Density	
	Designation	lbs/in.^{3}	(kg/m^3) x 10^3		Designation	lbs/in.^{3}	(kg/m^3) x 10^3
	1050	0.0975	2.705		1190	0.0975	2.700
	1050A	0.0975	2.705	+	1290	0.0975	2.700
	1060	0.0975	2.705		1193	0.0975	2.700
	1065	0.0975	2.700		1198	0.0975	2.700
	1070	0.0975	2.700		1199	0.0975	2.700
	1070A	0.0975	2.700		2001	0.102	2.82
	1080	0.0975	2.700		2002	0.099	2.73
	1080A	0.0975	2.700		2004	0.102	2.82
	1085	0.0975	2.700		2005	0.102	2.83
	1090	0.0975	2.700		2006	0.099	2.74
	1098	0.0975	2.700		2007	0.102	2.82
	1100	0.098	2.71		2007A	0.102	2.81
+	1100A	0.098	2.71		2008	0.098	2.72
	1200	0.098	2.70		2009	0.099	2.75
	1200A	0.098	2.71		2010	0.098	2.72
	1300	0.098	2.71		2011	0.102	2.83
	1110	0.098	2.70		2011A	0.102	2.82
	1120	0.098	2.71		2111	0.102	2.83
	1230	0.098	2.70		2111A	0.102	2.83
+	1230A	0.098	2.70		2111B	0.102	2.83
	1235	0.0975	2.705		2012	0.102	2.82
	1435	0.0980	2.710		2013	0.099	2.73
	1145	0.0975	2.700		2014	0.101	2.80
	1345	0.0975	2.705		2014A	0.101	2.80
	1445	0.0975	2.700		2214	0.101	2.80
	1150	0.0975	2.705		2015	0.102	2.83
	1350	0.0975	2.705		2016	0.101	2.79
	1350A	0.0975	2.700		2017	0.101	2.79
	1450	0.0975	2.705		2017A	0.101	2.79
	1370	0.0975	2.700		2117	0.099	2.75
	1275	0.0975	2.705		2018	0.102	2.82
	1185	0.0975	2.700		2218	0.101	2.81
	1285	0.0975	2.700		2618	0.100	2.76
	1385	0.0975	2.700		2618A	0.100	2.77
	1188	0.0975	2.700		2219	0.103	2.84

CALCULATED NOMINAL DENSITIES FOR ACTIVE WROUGHT ALUMINUM AND WROUGHT ALUMINUM ALLOYS (continued)

	Designation	Density lbs/in.^{3}	Density (kg/m^3) x 10^3
	2319	0.103	2.84
	2419	0.102	2.84
	2519	0.102	2.82
	2021	0.103	2.84
+	2022	0.101	2.80
+	2023	0.100	2.77
	2024	0.100	2.78
	2024A	0.100	2.77
	2124	0.100	2.78
	2224	0.100	2.77
	2224A	0.100	2.78
	2324	0.100	2.77
	2424	0.100	2.77
	2524	0.100	2.78
	2025	0.101	2.81
	2026	0.100	2.77
	2027	0.101	2.79
+	2028	0.102	2.83
	2030	0.102	2.81
	2031	0.100	2.77
+	2032	0.100	2.76
	2034	0.101	2.79
	2036	0.100	2.75
	2037	0.099	2.74
	2038	0.099	2.73
	2039	0.101	2.81
+	2139	0.102	2.81
	2040	0.102	2.81
+	2050	0.098	2.70
	2056	0.100	2.78
	2090	0.093	2.59
	2091	0.093	2.58
	2094	0.098	2.72
	2095	0.098	2.70
	2195	0.098	2.71
	2196	0.095	2.63
	2097	0.096	2.65
	2197	0.095	2.64
	2297	0.096	2.65
	2397	0.096	2.65
	2096	0.097	2.70
	2099	0.095	2.63
+	2198	0.097	2.69
+	2199	0.095	2.64
	3002	0.098	2.70
	3102	0.098	2.71
	3003	0.099	2.73
	3103	0.099	2.73
	3103A	0.098	2.72
	3103B	0.098	2.73
	3203	0.098	2.73
	3403	0.099	2.73
	3004	0.098	2.72
	3004A	0.098	2.71
	3104	0.098	2.72
	3204	0.098	2.71
	3304	0.098	2.72
	3005	0.098	2.73
	3005A	0.099	2.73
	3105	0.098	2.72
	3105A	0.098	2.71
	3105B	0.098	2.72
	3007	0.098	2.72
	3107	0.098	2.72
	3207	0.098	2.71
	3207A	0.098	2.72
	3307	0.098	2.72
	3009	0.099	2.73
	3010	0.098	2.72
+	3110	0.098	2.72
	3011	0.099	2.73
	3012	0.098	2.72
	3013	0.099	2.74
	3014	0.099	2.75
	3015	0.098	2.72
	3016	0.098	2.72
	3017	0.099	2.73
	3019	0.099	2.73
	3020	0.099	2.73
	3025	0.098	2.72
	3026	0.098	2.72
	3030	0.098	2.72
	3130	0.098	2.71
	4004	0.096	2.65
	4104	0.096	2.65
	4006	0.098	2.71
	4007	0.099	2.74
	4008	0.096	2.67
	4009	0.097	2.70
	4010	0.096	2.67
	4013	0.098	2.71
	4014	0.097	2.70
	4015	0.098	2.71
	4016	0.099	2.73
	4017	0.098	2.72
	4018	0.096	2.67
	4019	0.099	2.74
+	4020	0.098	2.71
	4026	0.099	2.73
	4032	0.097	2.68
	4043	0.097	2.69
	4043A	0.097	2.69
	4343	0.097	2.68
	4643	0.097	2.69
	4044	0.097	2.67
	4045	0.096	2.67
	4145	0.099	2.74
	4145A	0.099	2.74
	4046	0.096	2.66
	4047	0.096	2.66

CALCULATED NOMINAL DENSITIES FOR ACTIVE WROUGHT ALUMINUM AND WROUGHT ALUMINUM ALLOYS (continued)

	Designation	Density lbs/in.^{3}	Density (kg/m^3) x 10^3
	4047A	0.096	2.66
	4147	0.096	2.66
	5005	0.098	2.70
	5005A	0.097	2.69
	5205	0.097	2.70
	5305	0.097	2.69
	5505	0.097	2.69
	5605	0.097	2.69
	5006	0.098	2.71
	5106	0.098	2.71
	5010	0.098	2.71
	5110	0.097	2.69
+	5110A	0.098	2.70
	5210	0.097	2.69
	5310	0.097	2.69
	5016	0.097	2.70
	5017	0.097	2.69
	5018	0.096	2.67
	5018A	0.097	2.67
	5019	0.096	2.65
	5019A	0.096	2.65
	5119	0.096	2.65
	5119A	0.096	2.65
	5021	0.097	2.68
	5022	0.096	2.66
	5023	0.095	2.64
	5026	0.097	2.69
	5027	0.096	2.65
	5040	0.098	2.72
	5140	0.098	2.71
+	5041	0.097	2.67
	5042	0.096	2.67
	5043	0.098	2.72
	5049	0.097	2.70
	5149	0.097	2.69
	5249	0.097	2.70
	5349	0.097	2.70
	5449	0.097	2.70
	5050	0.097	2.69
	5050A	0.097	2.69
	5150	0.097	2.68
	5051	0.097	2.69
	5051A	0.097	2.69
	5151	0.097	2.68
	5251	0.097	2.69
	5251A	0.097	2.69
	5351	0.097	2.68
	5451	0.097	2.68
	5052	0.097	2.68
	5252	0.096	2.67
	5352	0.097	2.67
	5154	0.096	2.66
	5154A	0.096	2.67
	5154B	0.096	2.67
	5254	0.096	2.66
	5354	0.097	2.69
	5454	0.097	2.69
	5554	0.097	2.69
	5654	0.096	2.66
	5654A	0.096	2.66
	5754	0.097	2.67
	5954	0.096	2.66
	5056	0.095	2.64
	5356	0.096	2.64
	5356A	0.096	2.64
	5456	0.096	2.66
	5456A	0.096	2.66
	5456B	0.096	2.66
	5556	0.096	2.66
	5556A	0.096	2.65
	5556B	0.096	2.65
	5556C	0.096	2.66
	5257	0.097	2.70
	5457	0.097	2.69
	5557	0.097	2.70
	5657	0.097	2.69
	5058	0.097	2.67
	5059	0.096	2.66
	5070	0.097	2.68
	5180	0.097	2.70
	5180A	0.097	2.70
	5082	0.096	2.65
	5182	0.096	2.65
	5083	0.096	2.66
	5183	0.096	2.66
	5183A	0.096	2.66
	5283	0.096	2.65
	5283A	0.096	2.65
	5283B	0.096	2.66
	5383	0.096	2.66
	5483	0.096	2.66
	5086	0.096	2.66
	5186	0.096	2.66
	5087	0.096	2.66
	5187	0.096	2.66
	5088	0.096	2.65
	6101	0.097	2.70
	6101A	0.097	2.69
	6101B	0.097	2.70
	6201	0.097	2.69
	6201A	0.097	2.69
	6401	0.097	2.69
+	6501	0.098	2.70
	6002	0.097	2.70
	6003	0.097	2.70
	6103	0.098	2.70
	6005	0.097	2.70
	6005A	0.098	2.70
	6005B	0.097	2.70
+	6005C	0.098	2.70

CALCULATED NOMINAL DENSITIES FOR ACTIVE WROUGHT ALUMINUM AND WROUGHT ALUMINUM ALLOYS (continued)

	Designation	Density lbs/in.^{3}	Density (kg/m^3) x 10^3
	6105	0.097	2.70
	6205	0.098	2.71
	6006	0.098	2.70
	6106	0.098	2.70
	6206	0.098	2.71
	6306	0.097	2.70
	6008	0.098	2.70
	6009	0.098	2.71
	6010	0.098	2.71
	6110	0.098	2.71
	6110A	0.098	2.71
	6011	0.099	2.73
	6111	0.098	2.71
	6012	0.099	2.74
	6012A	0.099	2.74
	6013	0.098	2.71
	6113	0.098	2.71
	6014	0.098	2.70
	6015	0.097	2.69
	6016	0.098	2.70
	6016A	0.098	2.70
	6116	0.097	2.70
	6018	0.099	2.74
	6019	0.098	2.71
	6020	0.099	2.73
	6021	0.098	2.72
	6022	0.097	2.69
	6023	0.099	2.73
	6024	0.098	2.72
	6025	0.097	2.70
+	6026	0.099	2.74
	6033	0.099	2.73
	6040	0.099	2.73
	6151	0.098	2.71
	6351	0.098	2.71
	6351A	0.098	2.71
+	6451	0.098	2.70
	6951	0.098	2.70
	6053	0.097	2.69
	6056	0.098	2.72
	6156	0.098	2.72
	6060	0.097	2.70
	6160	0.097	2.70
	6260	0.098	2.70
	6360	0.098	2.70
	6460	0.097	2.70
	6560	0.098	2.70
	6061	0.098	2.70
	6061A	0.098	2.70
	6261	0.098	2.70
	6162	0.097	2.70
	6262	0.098	2.72
+	6262A	0.098	2.72
	6063	0.097	2.70
	6063A	0.097	2.70
	6463	0.097	2.69
	6463A	0.097	2.69
	6763	0.097	2.69
	6963	0.097	2.70
+	6065	0.098	2.72
	6066	0.098	2.72
	6069	0.098	2.70
	6070	0.098	2.71
	6081	0.097	2.70
	6181	0.097	2.69
	6181A	0.098	2.70
	6082	0.098	2.70
	6082A	0.098	2.70
+	6182	0.098	2.71
	6091	0.097	2.70
	6092	0.098	2.70
	7003	0.101	2.80
	7004	0.100	2.77
+	7204	0.100	2.78
	7005	0.100	2.77
	7108	0.100	2.78
	7108A	0.101	2.78
	7009	0.101	2.80
	7010	0.102	2.82
	7012	0.101	2.81
	7014	0.101	2.79
	7015	0.100	2.77
	7016	0.100	2.78
	7116	0.101	2.78
	7017	0.100	2.78
	7018	0.101	2.79
	7019	0.100	2.78
	7019A	0.100	2.75
	7020	0.100	2.78
	7021	0.101	2.78
	7022	0.100	2.77
	7122	0.100	2.78
	7023	0.100	2.78
	7024	0.100	2.77
	7025	0.100	2.77
	7026	0.100	2.78
	7028	0.100	2.77
	7029	0.100	2.77
	7129	0.100	2.78
	7229	0.100	2.77
	7030	0.101	2.79
	7031	0.099	2.74
	7032	0.102	2.82
	7033	0.101	2.79
	7034	0.105	2.90
	7035	0.099	2.75
+	7036	0.104	2.88
+	7136	0.104	2.88
	7039	0.099	2.74
	7040	0.102	2.82

CALCULATED NOMINAL DENSITIES FOR ACTIVE WROUGHT ALUMINUM AND WROUGHT ALUMINUM ALLOYS (continued)

	Designation	Density lbs/in.^{3}	Density (kg/m^3) x 10^3
+	7140	0.102	2.83
	7046	0.102	2.82
	7046A	0.102	2.81
	7049	0.103	2.84
	7049A	0.103	2.84
	7149	0.103	2.84
	7249	0.103	2.84
	7349	0.103	2.85
	7449	0.103	2.85
	7050	0.102	2.83
	7050A	0.102	2.82
	7150	0.102	2.83
	7250	0.102	2.82
	7055	0.103	2.86
+	7056	0.104	2.87
	7060	0.103	2.85
	7064	0.103	2.85
	7068	0.103	2.85
	7168	0.103	2.86
	7072	0.098	2.72
	7075	0.101	2.81
	7175	0.101	2.80
	7475	0.101	2.81
	7076	0.102	2.84
	7178	0.102	2.83
	7278	0.102	2.83
	7278A	0.102	2.82
+	7081	0.102	2.83
	7085	0.103	2.85
	7090	0.103	2.85
	7093	0.103	2.86
+	7095	0.104	2.89
	8005	0.098	2.71
	8006	0.099	2.74
	8007	0.100	2.76

	Designation	Density lbs/in.^{3}	Density (kg/m^3) x 10^3
	8008	0.099	2.74
	8010	0.098	2.72
	8011	0.098	2.71
	8011A	0.098	2.71
	8111	0.098	2.71
	8211	0.098	2.72
	8112	0.098	2.72
	8014	0.099	2.73
	8015	0.098	2.72
	8016	0.098	2.72
	8017	0.098	2.71
	8018	0.098	2.72
	8019	0.106	2.92
	8021	0.098	2.73
	8021A	0.098	2.72
	8021B	0.098	2.72
	8022	0.102	2.83
	8023	0.099	2.74
	8024	0.088	2.43
	8025	0.098	2.71
	8030	0.098	2.71
	8130	0.098	2.71
	8040	0.098	2.71
	8050	0.099	2.73
	8150	0.098	2.73
+	8076A	0.098	2.71
	8176	0.098	2.71
	8077	0.098	2.70
	8079	0.098	2.72
	8090	0.092	2.54
	8091	0.092	2.54
	8093	0.092	2.55

PREVIOUSLY ASSIGNED BUT PRESENTLY INACTIVE ALLOY DESIGNATIONS[19]

	DESIGNATION	DATE RECLASSIFIED
	1030[10]	1988-05-23
+	1035[10]	2005-04-13
+	1040[10]	2005-04-13
+	1045[10]	2005-04-13
	1130	1966-09-09
	1330	1964-12-18
	1135	1997-02-03
	1335	1966-09-09
	1245	1966-09-09
	1250	1988-05-23
	1055	1988-05-23
	1160	1958-04-22
	(Superseded by 1060)	
+	1260	2005-04-13
	1360	1965-12-09
	1165	1966-07-12
	1170	1997-02-03
	1270	1966-07-12
	1075[10]	1988-05-23
	1175	1997-02-03
	1180	1997-02-03
	1187	1958-09-10
	(Superseded by 1188)	
	1095	1988-05-23
	1197	1958-09-10
	(Superseded by 1199)	
	1099[10]	1965-12-09
	2003[10]	1997-11-28
	X2316[10]	1965-03-31
	X2119	1966-03-07
	2020	1974-11-01
	2225	1966-07-12
+	2048[10]	2005-04-13
	2053	1983-11-09
+	2080[10]	2005-06-02
	X2096[10]	2000-12-08
	3303	1997-02-03
	3205	1965-11-05
+	3006[10]	2005-04-13
	3008	1996-03-15
	3018	1998-01-16
	4001	1965-11-05
	4101	1965-11-05
	4002	1981-05-29
	X4003	1975-01-27
	X4005	1977-06-01
+	4011[10]	2005-06-02
	4012	1965-11-05
	4543	1997-02-03

	DESIGNATION	DATE RECLASSIFIED
	4245	1968-08-19
	(Redesignated 4048)	
+	4048[10]	2005-04-13
	X5002	1963-06-03
	5004	1967-04-26
	5105	1960-04-28
	5405	1966-07-12
	5007	1968-05-13
	5008	1968-05-13
	5009	1968-05-13
	5011	1967-04-26
	X5012	1970-06-30
	5013	1996-10-02
	5014[10]	1997-11-28
	X5015	1968-08-19
	X5020	1977-08-04
	X5220	1962-01-11
+	5025[10]	2005-06-02
	5034	1973-08-09
	5039	1975-11-24
+	5250	2005-04-13
	5050B	1996-03-15
	5152	1963-06-03
	X5452	1971-06-17
	5552	1997-02-03
+	5652	2005-04-13
	5053	1968-08-19
	X5153	1967-04-26
	5854	1996-10-02
	X5055	1956-10-19
	5155	1971-07-14
	5056A[52]	1992-02-21
+	5357	2005-04-13
	5757	1963-05-14
	5857	1963-06-10
	5957	1963-06-03
	X5080[10]	1963-10-22
	5280	1996-10-02
	X5084	1965-04-27
	X5184	1965-04-27
	X5085	1977-08-04
	X5090	1977-07-18
	5091[10]	2000-04-26
	6001[10]	1955-07-08
+	6301	2005-04-13
+	6004[10]	2005-04-13
+	6007[10]	2005-04-13
	6017[10]	1997-02-03

See footnotes on pages 13-14.

PREVIOUSLY ASSIGNED BUT PRESENTLY INACTIVE ALLOY DESIGNATIONS[19] (continued)

	DESIGNATION	DATE RECLASSIFIED
	X6030[10]	2001-01-25
	6051[10]	1963-12-12
	X6251	1985-03-31
	6253	2002-05-22
	X6161	1963-06-03
	6062[10]	1964-09-04
	X6163	1964-12-18
	6263	1955-07-12
	6363	1964-12-18
	6563	1967-04-26
	6663	1967-04-26
	6863	1996-10-02
	X6064	1965-03-31
	X6067	1974-11-01
	6071	1968-07-12
	6090	1992-08-01
	7001[10]	1997-02-03
	7002	1966-07-12
	7104	1988-05-23
	X7006	1963-09-10
	X7106[10]	1980-04-16
	X7007	1972-02-16
+	7008[10]	2005-04-13
	7109	1996-03-15
	7011[10]	1999-06-17
	7013[10]	1997-02-03
	7027	1998-06-26
	X7038	1967-04-26
	7139	1966-09-09
	7146	1997-02-03
	7051	1998-10-02
	7070	1988-05-23
	X7272	1965-03-31
	7472	1997-02-03
	X7275	1963-06-03
	7277[10]	2000-11-06
	7079	1989-03-22
	7179	1989-06-06
	X7279	1963-06-03
	X7080	1971-01-04
	7091[10]	1997-02-03
	8001[10]	1997-02-03
	X8002	1964-12-18
	X8003	1964-12-18
	8004	1996-10-02
	8009[10]	2000-06-19
	8212	1967-04-26
	8013	1971-11-01
+	8020[10]	2005-04-13

	DESIGNATION	DATE RECLASSIFIED
+	8076[10]	2005-04-13
	8276	1996-10-02
	8177	1997-02-03
+	8280[10]	2005-04-13
	X8380	1964-12-18
	X8480	1964-12-18
	8081[10]	1997-02-03
	X8090A	1989-01-13
	X8092	1991-10-24
	X8192	1991-10-24

See footnotes on pages 13-14.

REGISTERED CHEMICAL COMPOSITION LIMITS OF INACTIVE ORIGINAL ALLOYS[1,2]

	REGISTERED DESIGNATION	REGISTTERED BY	Si	Fe	Cu	Mn	Mg	Cr	Ni	Zn	Ti	Ga	V		OTHERS[35]		ALUMINUM
															Each	Total[3]	Minimum
	1030	USA	0.35	0.6	0.10	0.05	0.05	---	---	0.10	0.03	---	0.05	---	0.03	---	99.30[4]
+	1035	USA	0.35	0.6	0.10	0.05	0.05	---	---	0.10	0.03	---	0.05	---	0.03	---	99.35[4]
+	1040	USA	0.30	0.50	0.10	0.05	0.05	---	---	0.10	0.03	---	0.05	---	0.03	---	99.40[4]
+	1045	USA	0.30	0.45	0.10	0.05	0.05	---	---	0.05	0.03	---	0.05	---	0.03	---	99.45[4]
	1075	USA	0.28	0.20	0.04	0.03	0.03	---	---	0.04	0.03	---	0.05	---	0.03	---	99.75[4]
	1099	USA	---	---	---	---	---	---	---	---	---	---	---	---	---	---	99.99[5]
	2003	EAA	0.30	0.30	4.0-5.0	0.30-0.8	0.02	---	---	0.10	0.15	---	0.05-0.20	0.10-0.25 Zr[35]	0.05	0.15	Remainder
	X2316	USA	0.50-1.5	1.2	3.5-5.0	0.50-1.0	0.30-0.6	---	0.6	0.8	---	---	---	0.30 Pb	0.15	0.30	Remainder
+	2048	USA	0.15	0.20	2.8-3.8	0.20-0.6	1.2-1.8	---	---	0.25	0.10	---	---	---	0.05	0.15	Remainder
+	2080	USA	0.10	0.20	3.3-4.1	0.25	1.5-2.2	---	---	0.10	---	---	---	0.08-0.25 Zr[45]	0.05	0.15	Remainder
	X2096	USA	0.12	0.15	2.3-3.0	0.25	0.25-0.8	---	---	0.25	0.10	---	---	0.04-0.18 Zr[40]	0.05	0.15	Remainder
+	3006	USA	0.50	0.7	0.10-0.30	0.50-0.8	0.30-0.6	0.20	---	0.15-0.40	0.10	---	---	---	0.05	0.15	Remainder
+	4011	USA	6.5-7.5	0.20	0.20	0.10	0.45-0.7	---	---	0.10	0.04-0.20	---	---	0.04-0.07 Be	0.05	0.15	Remainder
+	4048	USA	9.3-10.7	0.8	3.3-4.7	0.07	0.07	0.07	---	9.3-10.7	---	---	---	6	0.05	0.15	Remainder
	5014	EAA	0.40	0.40	0.20	0.20-0.9	4.0-5.5	0.20	---	0.7-1.5	0.20	---	---	---	0.05	0.15	Remainder
+	5025	USA	0.25	0.25	0.10	0.20	4.5-6.0	0.20	---	0.25	0.05-0.20	---	---	0.10-0.25 Zr[32]	0.05	0.15	Remainder
	X5080	USA	0.35 Si + Fe		0.10	0.20-0.7	3.5-4.5	0.05-0.20	---	1.7-2.8	0.20	---	---	---	0.05	0.15	Remainder
	5091	USA	0.20	0.30	---	---	3.7-4.2	---	---	---	---	---	---	56	0.05	0.15	Remainder
	6001	USA	0.35-0.7	0.6	0.10	0.03	0.35-0.7	0.03	---	0.10	---	---	---	---	0.03	0.10	Remainder
+	6004	USA	0.30-0.6	0.10-0.30	0.10	0.20-0.6	0.40-0.7	---	---	0.05	---	---	---	---	0.05	0.15	Remainder
+	6007	USA	0.9-1.4	0.7	0.20	0.05-0.25	0.6-0.9	0.05-0.25	---	0.25	0.15	---	---	0.05-0.20 Zr	0.05	0.15	Remainder
	6017	USA	0.55-0.7	0.15-0.30	0.05-0.20	0.10	0.45-0.6	0.10	---	0.05	0.05	---	---	---	0.05	0.15	Remainder
	X6030	USA	0.40-0.8	0.7	0.15-0.40	0.15	0.8-1.2	0.04-0.35	---	0.25	0.15	---	---	37	0.05	0.15	Remainder
	6051	USA	0.6-1.2	1.0	0.15	0.20	0.45-0.8	---	---	0.25	---	---	---	---	0.05	0.15	Remainder
	6062	USA	0.40-0.8	0.7	0.15-0.40	0.15	0.8-1.2	0.04-0.14	---	0.25	0.15	---	---	---	0.05	0.15	Remainder
	7001	USA	0.35	0.40	1.6-2.6	0.20	2.6-3.4	0.18-0.35	---	6.8-8.0	0.20	---	---	---	0.05	0.15	Remainder
	X7106	USA	0.20	0.30	0.10	0.10-0.40	2.0-2.8	0.06-0.20	---	4.0-4.8	0.01-0.06	---	---	0.10-0.20 Zr	0.05	0.15	Remainder
+	7008	USA	0.10	0.10	0.05	0.05	0.7-1.4	0.12-0.25	---	4.5-5.5	0.05	---	---	---	0.05	0.10	Remainder
	7011	USA	0.15	0.20	0.05	0.10-0.30	1.0-1.6	0.05-0.20	---	4.0-5.5	0.05	---	---	---	0.05	0.15	Remainder
	7013	USA	0.6	0.7	0.10	1.0-1.5	---	---	---	1.5-2.0	---	---	---	---	0.05	0.15	Remainder
	7277	USA	0.50	0.7	0.8-1.7	---	1.7-2.3	0.18-0.35	---	3.7-4.3	0.10	---	---	---	0.05	0.15	Remainder
	7091	USA	0.12	0.15	1.1-1.8	---	2.0-3.0	---	---	5.8-7.1	---	---	---	0.20-0.6 Co[31]	0.05	0.15	Remainder
	8001	USA	0.17	0.45-0.7	0.15	---	---	---	0.9-1.3	0.05	---	---	---	13	0.05	0.15	Remainder
	8009	USA	1.7-1.9	8.4-8.9	---	0.10	---	0.10	---	0.25	0.10	---	1.1-1.5	50	0.05	0.15	Remainder
+	8020	USA	0.10	0.10	0.005	0.005	---	---	---	0.005	---	---	0.05	11	0.03	0.10	Remainder
+	8076	USA	0.10	0.6-0.9	0.04	---	0.08-0.22	---	---	0.05	---	---	---	0.04 B	0.03	0.10	Remainder
+	8280	USA	1.0-2.0	0.7	0.7-1.3	0.10	---	---	0.20-0.7	0.05	0.10	---	---	5.5-7.0 Sn	0.05	0.15	Remainder
	8081	USA	0.7	0.7	0.7-1.3	0.10	---	---	---	0.05	0.10	---	---	18.0-22.0 Sn	0.05	0.15	Remainder

See footnotes on pages 13-14.

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CROSS REFERENCE OF INTERNATIONAL DESIGNATIONS

DECLARATION OF ACCORD (DOA) TO ISO*

DOA DESIGNATION	ISO DESIGNATION	DOA DESIGNATION	ISO DESIGNATION	DOA DESIGNATION	ISO DESIGNATION
1050A	Al99.5	3105	AlMn0.5Mg0.5	6101	E-AlMgSi
1350	E-Al99.5	4043	AlSi5	6101A	E-AlMgSi(A)
1060	Al99.6	4043A	AlSi5(A)	6005	AlSiMg
1070A	Al99.7	4047	AlSi12	6005A	AlSiMg(A)
1370	E-Al99.7	4047A	AlSi12(A)	6351	AlSi1Mg0.5Mn
1080A	Al99.8(A)	5005	AlMg1(B)	6060	AlMgSi
1100	Al99.0Cu	5019	AlMg5	6061	AlMg1SiCu
1200	Al99.0	5050	AlMg1.5(C)	6262	AlMg1SiPb
2011	AlCu6BiPb	5251	AlMg2	6063	AlMg0.7Si
2014	AlCu4SiMg	5052	AlMg2.5	6063A	AlMg0.7Si(A)
2014A	AlCu4SiMg(A)	5154	AlMg3.5	6181	AlSi1Mg0.8
2017	AlCu4MgSi	5154A	AlMg3.5(A)	6082	AlSi1MgMn
2017A	AlCu4MgSi(A)	5454	AlMg3Mn	7005	AlZn4.5Mg1.5Mn
2117	AlCu2.5Mg	5554	AlMg3Mn(A)	7010	AlZn6MgCu
2219	AlCu6Mn	5754	AlMg3	7020	AlZn4.5Mg1
2024	AlCu4Mg1	5056	AlMg5Cr	7049A	AlZn8MgCu
2030	AlCu4PbMg	5356	AlMg5Cr(A)	7050	AlZn6CuMgZr
3003	AlMn1Cu	5456	AlMg5Mn1	7075	AlZn5.5MgCu
3103	AlMn1	5083	AlMg4.5Mn0.7	7475	AlZn5.5MgCu(A)
3004	AlMn1Mg1	5183	AlMg4.5Mn0.7(A)	7178	AlZn7MgCu
3005	AlMn1Mg0.5	5086	AlMg4		

*Source: ISO 209-1.

The Aluminum Association
1525 Wilson Boulevard
Arlington, VA 22209
U.S.A.

RECOMMENDATION
INTERNATIONAL DESIGNATION SYSTEM FOR WROUGHT ALUMINUM AND WROUGHT ALUMINUM ALLOYS

15 December 1970
Revised March 2002

This Recommendation is based on the numerical designation system for wrought aluminum and wrought aluminum alloys which was adopted in the U.S.A. in 1954, and became its national standard in 1957. This Recommendation was officially adopted by the International Signatories of the Declaration of Accord on December 15, 1970.

Designations in accordance with this Recommendation may be used by any country, but there is no obligation to use them. For use, see Appendixes A, B, and C.

A numerical designation assigned in conformance with this Recommendation should only be used to indicate an aluminum or an aluminum alloy having chemical composition limits identical to those registered with the Signatories to the Declaration of Accord on an International Alloy Designation System for Wrought Aluminum and Wrought Aluminum Alloys.

1. Scope

This recommendation describes a four-digit numerical system for designating wrought aluminum and wrought aluminum alloys.

2. Alloy Groups

The first of the four digits in the designation indicates the alloy group as follows:

Aluminum, 99.00 percent and greater 1xxx

Aluminum alloys grouped by major alloying elements[1,2,3]

- Copper 2xxx
- Manganese 3xxx
- Silicon 4xxx
- Magnesium 5xxx
- Magnesium and Silicon 6xxx
- Zinc 7xxx
- Other elements 8xxx

Unused series 9xxx

3. 1xxx Group

The designation assigned shall be in the 1xxx group whenever the minimum aluminum content is specified as 99.00 percent and greater. In the 1xxx group, the last two of the four digits in the designation indicate the minimum aluminum percentage[4]. These digits are the same as the two digits to the right of the decimal point in minimum aluminum percentage when it is expressed to the nearest 0.01 percent. The second digit in the alloy designation indicates alloy modifications in impurity limits or alloying elements. If the second digit in the designation is zero, it indicates unalloyed aluminum having natural impurity limits; integers 1 through 9, which are assigned consecutively as needed, indicate special control of one or more individual impurities or alloying elements.

4. 2xxx-8xxx Groups

The alloy designation in the 2xxx through 8xxx groups is determined by the alloying element (Mg_2Si for 6xxx alloys) present in the greatest mean percentage. If the greatest mean percentage is common to more than one alloying element, choice of group will be in order of group sequence Cu, Mn, Si, Mg, Mg_2Si, Zn or Others. In the 2xxx through 8xxx alloy groups the last two of the four digits in the designation have no special significance but serve only to identify the different aluminum alloys in the group. The second digit in the alloy designation indicates the original alloy[5] and alloy modifications; integers 1 through 9, which are assigned consecutively, indicate alloy modifications.

5. Modifications

A modification of the original alloy[5] is limited to any one or a combination of the following:

(a) Change of not more than the following amounts in the arithmetic mean of the limits for an individual alloying element or combination of elements expressed as an alloying element or both:

Arithmetic Mean of Limits for Alloying Elements in Original Alloy	Maximum Change
Up through 1.0 percent	0.15
Over 1.0 through 2.0 percent	0.20
Over 2.0 through 3.0 percent	0.25
Over 3.0 through 4.0 percent	0.30
Over 4.0 through 5.0 percent	0.35
Over 5.0 through 6.0 percent	0.40
Over 6.0 percent	0.50

To determine compliance when maximum and minimum limits are specified for a combination of two or more elements in one alloy composition, the arithmetic mean of such combination is compared to the sum of the mean values of the same individual elements, or any combination thereof, in another alloy composition.

(b) Addition or deletion of not more than one alloying element with limits having an arithmetic mean of not more than 0.30 percent, or addition or deletion of not more than one combination of elements expressed as an alloying element with limits having a combined arithmetic mean of not more than 0.40 percent.

(c) Substitution of one alloying element for another element serving the same purpose.

(d) Change in limits for impurities expressed singly or as a combination.

(e) Change in limits for grain refining elements.

(f) Maximum iron or silicon limits of 0.12 percent and 0.10 percent, or less, respectively, reflecting high purity base metal.

An alloy should not be registered as a modification if it meets the requirements for a national variation.

6. National Variations

National variations of wrought aluminum and wrought aluminum alloys registered by another country in accordance with this Recommendation are identified by a serial letter after the numerical designation. The serial letters are assigned in alphabetical sequence starting with A for the first national variation registered, but omitting I, O, and Q.

A national variation has composition limits which are similar but not identical to those registered by another country, with differences such as:

(a) Differences in arithmetic mean of limits for an individual alloying element or combination of elements expressed as an alloying element, or both, not exceeding the following amounts:

Arithmetic Mean of Limits for Alloying Elements in Original Alloy or Modification	Maximum Difference
Up through 1.0 percent	0.15
Over 1.0 through 2.0 percent	0.20
Over 2.0 through 3.0 percent	0.25
Over 3.0 through 4.0 percent	0.30
Over 4.0 through 5.0 percent	0.35
Over 5.0 through 6.0 percent	0.40
Over 6.0 percent	0.50

To determine compliance when maximum and minimum limits are specified for a combination of two or more elements in one alloy composition, the arithmetic mean of such combination is compared to the sum of the mean values of the same individual elements, or any combination thereof, in another alloy composition.

(b) Substitution of one alloying element for another element serving the same purpose.

(c) Different limits of impurities except for low iron. Iron maximum of 0.12 percent or less, reflecting high purity base metal, should be considered an alloy modification. See 5(f).

(d) Different limits on grain refining elements.

(e) Inclusion of a minimum limit for iron or silicon, or both.

An alloy meeting these requirements should not be registered as a new alloy or alloy modification.

See footnotes on page 25

FOOTNOTES

1. For codification purposes an alloying element is any element which is intentionally added for any purpose other than grain refinement and for which minimum and maximum limits are specified.

2. Standard limits for alloying elements and impurities are expressed to the following places:

Less than 0.001 percent	0.000X
0.001 but less than 0.01 percent	0.00X
0.01 but less than 0.10 percent	
Unalloyed aluminum made by a refining process	0.0XX
Alloys and unalloyed aluminum not made by a refining process	0.0X
0.10 through 0.55 percent	0.XX
(It is customary to express limits of 0.30 through 0.55 percent as 0.X0 or 0.X5.)	
Over 0.55 percent	0.X; X.X; etc.
(except that combined Si + Fe limits for 1xxx designations must be expressed as 0.XX or 1.XX)	

3. Standard limits for alloying elements and impurities are expressed in the following sequence: Silicon; Iron; Copper; Manganese; Magnesium; Chromium; Nickel; Zinc; Titanium (See Note 1); Other (See Note 2) Elements, Each; Other Elements, Total; Aluminum (See Note 3).

   Note 1—Additional specified elements having limits are inserted in alphabetical order by their chemical symbols between Titanium and Other Elements, Each, or are specified in footnotes.

   Note 2—"Others" includes listed elements for which no specific limit is shown as well as unlisted metallic elements. The producer may analyze samples for trace elements not specified in the registration or specification; however, such analysis is not required and may not cover all metallic "Others" elements. Should any analysis by the producer or the purchaser establish that an "Others" element exceeds the limit of "Each" or that the aggregate of several "Others" elements exceeds the limit of "Total", the material shall be considered non-conforming.

   Note 3—Aluminum is specified as minimum for unalloyed aluminum, and as a remainder for aluminum alloys.

4. The aluminum content for unalloyed aluminum made by a refining process is the difference between 100.00 percent and the sum of all other metallic elements plus silicon present in amounts of 0.0010 percent or more, each expressed to the third decimal before determining the sum, which is rounded to the second decimal before subtracting; for unalloyed aluminum not made by a refining process it is the difference between 100.00 percent and the sum of all other analyzed metallic elements plus silicon present in amounts of 0.010 percent or more, each expressed to the second decimal before determining the sum. For unalloyed aluminum made by a refining process, when the specified maximum limit is 0.0XX, an observed value or a calculated value greater than 0.0005 but less than 0.0010 percent is rounded off and shown as "less than 0.001". For alloys and unalloyed aluminum not made by a refining process, when the specified maximum limit is 0.XX, an observed value or a calculated value greater than 0.005 but less than 0.010 percent is rounded off and shown as "less than 0.01".

5. The term "original" alloy as used in the Registration Record is defined based on the following guidelines:

   (a) Only one alloy in any alloy family (having the same first, third and fourth digits) is considered the "original" alloy, and it is always used as the basis for registration of a modification.

   (b) All active and inactive alloys whose second digit is "0" are considered the "original" alloys for each specific alloy family.

   (c) For those alloy families with no second digit "0" registered, the alloy with the lowest second digit is considered the "original" alloy whether the alloy is active or inactive and a note (10)* is added following the designation. No registration shall be granted for a designation with a lower second digit for these alloy families.

   (d) No designation changes are made to any and all of the currently registered original alloys whether active or inactive.

* See footnote 10 on page 13.

APPENDIX A

USE OF DESIGNATIONS

A.1 All countries using designations in accordance with this Recommendation should use the same numerical designation for those wrought aluminum or wrought aluminum alloys having identical chemical composition limits. They should register the limits and the designations should be used by all other countries using these designations.

A.2 A numerical designation should be used without a suffix letter to indicate the initial chemical composition limits registered for that numerical designation.

A.3 A numerical designation should be used with a serial suffix letter to indicate chemical composition limits which are different from but closely similar to the initial chemical composition limits registered for that numerical designation by another country. Such designations shall be considered to be national variations.

A.4 A new numerical designation should be assigned only for wrought aluminum or a wrought aluminum alloy having chemical composition limits significantly different from other wrought aluminum or wrought aluminum alloys for which designations have previously been assigned.

A.5 Designations should be allotted in the following order of precedence:

A.5.1 The registered designation should be used if composition limits are identical to those previously registered by another country.

A.5.2 A suffix letter should be used with the previously registered numerical designation for an alloy if composition limits meet the requirements for a national variation .

A.5.3 The numerical designation for an alloy modification should be assigned if the composition limits meet the requirements for an alloy modification unless the limits also meet the requirements for a national variation.

A.5.4 A new numerical designation should be assigned only for a significantly different alloy composition exceeding the allowable limits for a national variation and modification from any original alloy and not meeting the requirements A.5.2 or A.5.3. In this case a number must be assigned which has not been used and which will not be assigned by any other country using numerical designations conforming to this Recommendation.

APPENDIX B

DEACTIVATION OF REGISTERED ALLOYS

B.1 All countries using designations in accordance with this Recommendation should review, at least once in every five years, the alloys registered by them to see if these alloys are still commercially active. If not, alloys should be proposed for deactivation. Any inactive alloy can still be reactivated when such need arises.

APPENDIX C

GENERAL GUIDELINES FOR DETERMINING COMPLIANCE WITH "SALE OF ALLOY" AND "COMMERCIAL QUANTITY" FOR PURPOSES OF REGISTERING WROUGHT ALUMINUM AND WROUGHT ALUMINUM ALLOYS

(See Declaration of Accord, Item 1)

C.1 Sale of Alloy

Sale of an alloy shall have been made to external users/customers (i.e., internal use and/or transfer of an alloy within a company does not meet the stated criteria).

C.2 Commercial Quantity

C.2.1 The alloy has undergone bona fide mill production and is NOT a "laboratory" scale volume used for evaluations or experimental purposes.

C.2.2 The alloy is cast and fabricated in standard production facilities and is NOT a one-time production.

C.2.3 There is an expected and ongoing commercial demand and/or need for the alloy.

C.2.4 The alloy must be purchased and sold in a standard business context which indicates that the alloy is actually "sold" and not "given away" for uses such as promotional evaluations.

DECLARATION OF ACCORD ON AN INTERNATIONAL ALLOY DESIGNATION SYSTEM FOR WROUGHT ALUMINUM AND WROUGHT ALUMINUM ALLOYS

It is agreed by the parties hereto that the following rules will apply in assigning alloy designations in accordance with the recommendation dated December 15, 1970 and revised March 2002 for an International Designation System for Wrought Aluminum and Wrought Aluminum Alloys:

1. To be eligible for registration, an aluminum or aluminum alloy shall be offered for sale currently and shall have been supplied in the previous twelve months, in both cases in commercial quantities. The complete composition limits must be registered and the former designation if any, should be shown.

2. All requests for international registration must be submitted to The Aluminum Association by a signatory of the Declaration of Accord. The signatory, in carrying out this function, will endeavor to restrict registrations to those required for international, regional or national standards or standards of equivalent importance in the commercial field. In view of its historic usage of these designations, more latitude is ceded to The Aluminum Association in this regard.

3. It will be the duty of each signatory to inform all other signatories of proposed composition limits or proposed changes in limits. Number assignments will be made by The Aluminum Association when negotiations on composition limits are complete among all signatories to the Declaration of Accord.

4. No designation or chemical composition limits will become final until at least 60 days after announcement to all participating organizations. During this 60-day period, all questions and objections regarding the designation or chemical composition limits must be submitted; or an extension of the period must be requested. Technical objections must be substantially resolved prior to final registration.

5. Only the organization that registered the designation may make a change in chemical composition limits for the alloy, and when a change is proposed, all participating organizations must be notified and given 60 days to comment.

6. After the 60-day period the registering organization shall confirm the registered designation and the composition limits to each participating organization.

7. This Declaration of Accord may be executed in several counterparts and all so executed shall constitute one agreement.

Organization

Representative

Address

Date

Signature

DECLARATION D'ACCORD SUR UN SYSTEME DE DESIGNATION INTERNATIONALE POUR L'ALUMINIUM CORROYE ET SES ALLIAGES

Il est convenu entre les participants que les règles suivantes seront appliquées dans la désignation des alliages, en concordance avec la recommandation du 15 décembre 1970, révisée en mars 2002, pour un système de désignation internationale pour l'aluminium et ses alliages corroyés:

1. Pour être admis à l'enregistrement, un aluminium ou alliage d'aluminium doit être alors offert en vente et avoir été fourni au cours des douze derniers mois, en quantités commerciales dans les deux cas. Les limites de composition chimique et la designation, s'il en existe une, doivent être enregistrées.

2. Toute demande d'enregistrement international doit être soumise à l'Aluminum Association par un signataire de la Déclaration d'Accord. Ledit signataire, dans l'exercice de cette fonction, s'appliquera à limiter les enregistrements à ceux requis pour les normes internationales, régionales ou nationales, ou autres normes d'importance équivalente dans le secteur commercial. Compte tenu de l'utilisation historique de ces désignations, l'Aluminum Association dispose à cet égard d'une assez grande latitude.

3. Il appartiendra à chaque signataire d'informer les organisations correspondantes de tous les pays participants des limites de composition proposées ou des changements proposés de ces limites. Les attributions de numéros seront effectuées par l'Aluminum Association dès l'achèvement des négociations sur les limites de composition par tous les signataires de la Déclaration d'Accord.

4. Aucune désignation ou limites de composition chimique ne deviendra definitive avant moins 60 jours à compter de la date l'information donnée aux organisations participantes. Durant ces 60 jours, toutes questions et objections concernant cette désignation ou limites de composition chimique devront être soumises; ou une extension de la période devra demandée. Toutes objections techniques devront être resolues de facon substantielle avant l'enregistrement final.

5. Seule l'organisation qui a enregistrée la designation peut faire un changement dans les limites de composition chimique de l'alliage; lorsqu'un changement est proposé, toutes les organisations participantes doivent être avisées et doivent présenter leurs remarques sous 60 jours.

6. Après la période de 60 jours l'organisation enregistrante confirmera la désignation enregistrée et les limites de composition à chaque organisation participante.

7. Cette Déclaration d'Accord pourra être reproduite en plusieurs exemplaires tout en constituant un seul agrément.

Organization

Representative

Address

Date

Signature

OTHER ALUMINUM ASSOCIATION REGISTRATION RECORDS AND REFERENCES

- **REGISTRATION RECORD OF INTERNATIONAL DESIGNATIONS AND CHEMICAL COMPOSITION LIMITS FOR UNALLOYED ALUMINUM** (Gold Sheets).
- **REGISTRATION RECORD OF ALUMINUM ASSOCIATION ALLOY DESIGNATIONS AND CHEMICAL COMPOSITION LIMITS FOR ALUMINUM ALLOYS IN THE FORM OF CASTINGS AND INGOT** (Pink Sheets).
- **REGISTRATION RECORD OF ALUMINUM ASSOCIATION DESIGNATIONS AND CHEMICAL COMPOSITION LIMITS FOR ALUMINUM HARDENERS** (Gray Sheets).
- **COMPONENTS OF CLAD ALUMINUM ALLOY PRODUCTS** (Lt. Green Sheets).
- **TEMPERS FOR ALUMINUM AND ALUMINUM ALLOY PRODUCTS** (Yellow Sheets).
- **TEMPERS FOR ALUMINUM AND ALUMINUM ALLOY PRODUCTS—METRIC EDITION** (Tan Sheets).
- **ALUMINUM STANDARDS AND DATA**
  A reference book containing data on chemical compositions, mechanical and physical properties, tolerances and other information on aluminum mill products in general use, in US customary units.
- **ALUMINUM STANDARDS AND DATA Metric SI**
  A reference book containing data on chemical compositions, mechanical and physical properties, tolerances and other information on aluminum mill products in general use, in metric units.

An Aluminum Association Publication and Audio Visual Price List can be ordered by calling: (301) 645-0756.

On-line ordering of The Aluminum Association publications is available through our website: www.aluminum.org.

PS/1000/0406/A-1

Exhibit 11

UNITED STATES DISTRICT COURT

DISTRICT OF DELAWARE

PECHINEY RHENALU, Plaintiff, -against- ALCOA, INC., Defendant.	Civil Action No. 99-301-SLR

DEFENDANT'S OBJECTIONS AND RESPONSES TO PLAINTIFF PECHINEY RHENALU'S FIRST SET OF REQUESTS FOR THE PRODUCTION OF DOCUMENTS

Pursuant to Rules 26 and 34 of the Federal Rules of Civil Procedure, and Local Rule 26.1(c) of the District of Delaware, Defendant Alcoa, Inc. ("Alcoa") objects and responds to plaintiff Pechiney Rhenalu's First Set of Requests for the Production of Documents ("the Document Requests") as follows:

General Objections

1. Alcoa objects to the Document Requests on the grounds and to the extent that they purport to require identification and disclosure of documents and information that were prepared in anticipation of litigation, constitute attorney work product, reveal privileged attorney-client communications, or are otherwise protected from disclosure under applicable privileges, laws, or rules. Alcoa hereby claims such privileges and protections to the extent

Exhibit 11

UNITED STATES DISTRICT COURT

DISTRICT OF DELAWARE

PECHINEY RHENALU,

Plaintiff,

-against-

ALCOA, INC.,

Defendant.

Civil Action No. 99-301-SLR

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General Objections

1. Alcoa objects to the Document Requests on the grounds and to the extent that they purport to require identification and disclosure of documents and information that were prepared in anticipation of litigation, constitute attorney work product, reveal privileged attorney-client communications, or are otherwise protected from disclosure under applicable privileges, laws, or rules. Alcoa hereby claims such privileges and protections to the extent

implicated by each document request, and excludes privileged and protected information from its responses to the Document Requests. Any disclosure of such protected or privileged information is inadvertent, and is not intended to waive those privileges or protections.

2. Alcoa objects to the Document Requests on the grounds and to the extent that they are overbroad and unduly burdensome. For example, Alcoa objects to the Document Requests insofar as they purport to seek all documents from January 1, 1960, nearly forty years ago. Alcoa will conduct a reasonable search for documents responsive to the portions of the Document Requests to which Alcoa does not object.

3. Alcoa objects to the Document Requests on the grounds and to the extent that they call for the provision of information that is not relevant to the subject matter of the pending action.

4. Alcoa objects to the Document Requests on the grounds and to the extent that they call for the provision of information that is not reasonably calculated to lead to the discovery of admissible evidence.

5. Alcoa objects to the Document Requests, and to the Instructions and Definitions therein, on the grounds and to the extent that they purport to impose any obligation on Alcoa that is beyond the scope of Rules 26 and 34 of the Federal Rules of Civil Procedure or other applicable law.

6. Alcoa objects to paragraph D of the Document Requests' Instructions and Definitions to the extent that it purports to impose any obligation on Alcoa that is beyond the scope of Rule 26(b)(5) of the Federal Rules of Civil Procedure or other applicable law.

7. Alcoa objects to the Document Requests on the grounds and to the extent that they purport to require Alcoa to search for and produce, or to identify, documents that are not in Alcoa's possession, custody, or control. For example, Alcoa objects on these grounds to the Document Requests that seek "all documents" relating to a particular subject matter since January 1, 1960. Alcoa has offices throughout the world which may contain one or more documents that may be responsive to such requests. The search Alcoa conducts will be limited to locations and files at the facilities where Alcoa deems it reasonably likely that responsive documents will be found.

8. Alcoa objects to the Document Requests on the grounds and to the extent that they purport to require the disclosure of confidential information (including, without limitation, confidential business information, trade secrets, or information subject to any confidentiality agreement, order and/or obligation) without entry by the Court of an appropriate confidentiality order. Pending entry of such an order, Alcoa will produce confidential

information to plaintiff pursuant to Local Rule 26.2 of the District of Delaware.

9. Alcoa objects to the Document Requests insofar as they assume disputed facts or legal conclusions in defining the documents requested. Alcoa hereby denies any such disputed facts or legal conclusions to the extent assumed by each document request. Any response or objection, including any production of documents, by Alcoa with respect to any such document request is without prejudice to this objection.

10. Alcoa's objections and responses to the Document Requests, including any production of documents, are not intended to waive or prejudice any objections Alcoa may assert now or in the future, including, without limitation, objections as to the relevance of the subject matter of any document request, or of the admissibility of any response or document, or category of responses or documents, at trial. Alcoa expressly reserves any and all rights and privileges under the Federal Rules of Civil Procedure, the Federal Rules of Evidence and any other law or rule, and the failure to assert such rights and privileges or the inadvertent disclosure by Alcoa of information protected by such rights or privileges shall not constitute a waiver thereof, either with respect to these

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UNITED STATES DISTRICT COURT

DISTRICT OF DELAWARE

PECHINEY RHENALU,

Plaintiff,

-against-

ALCOA, INC.,

Defendant.

Civil Action No. 99-301-SLR

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Pursuant to Rules 26 and 34 of the Federal Rules of Civil Procedure, and Local Rule 26.1(c) of the District of Delaware, Defendant Alcoa, Inc. ("Alcoa") objects and responds to plaintiff Pechiney Rhenalu's First Set of Requests for the Production of Documents ("the Document Requests") as follows:

General Objections

1. Alcoa objects to the Document Requests on the grounds and to the extent that they purport to require identification and disclosure of documents and information that were prepared in anticipation of litigation, constitute attorney work product, reveal privileged attorney-client communications, or are otherwise protected from disclosure under applicable privileges, laws, or rules. Alcoa hereby claims such privileges and protections to the extent

implicated by each document request, and excludes privileged and protected information from its responses to the Document Requests. Any disclosure of such protected or privileged information is inadvertent, and is not intended to waive those privileges or protections.

2. Alcoa objects to the Document Requests on the grounds and to the extent that they are overbroad and unduly burdensome. For example, Alcoa objects to the Document Requests insofar as they purport to seek all documents from January 1, 1960, nearly forty years ago. Alcoa will conduct a reasonable search for documents responsive to the portions of the Document Requests to which Alcoa does not object.

3. Alcoa objects to the Document Requests on the grounds and to the extent that they call for the provision of information that is not relevant to the subject matter of the pending action.

4. Alcoa objects to the Document Requests on the grounds and to the extent that they call for the provision of information that is not reasonably calculated to lead to the discovery of admissible evidence.

5. Alcoa objects to the Document Requests, and to the Instructions and Definitions therein, on the grounds and to the extent that they purport to impose any obligation on Alcoa that is beyond the scope of Rules 26 and 34 of the Federal Rules of Civil Procedure or other applicable law.

6. Alcoa objects to paragraph D of the Document Requests' Instructions and Definitions to the extent that it purports to impose any obligation on Alcoa that is beyond the scope of Rule 26(b)(5) of the Federal Rules of Civil Procedure or other applicable law.

7. Alcoa objects to the Document Requests on the grounds and to the extent that they purport to require Alcoa to search for and produce, or to identify, documents that are not in Alcoa's possession, custody, or control. For example, Alcoa objects on these grounds to the Document Requests that seek "all documents" relating to a particular subject matter since January 1, 1960. Alcoa has offices throughout the world which may contain one or more documents that may be responsive to such requests. The search Alcoa conducts will be limited to locations and files at the facilities where Alcoa deems it reasonably likely that responsive documents will be found.

8. Alcoa objects to the Document Requests on the grounds and to the extent that they purport to require the disclosure of confidential information (including, without limitation, confidential business information, trade secrets, or information subject to any confidentiality agreement, order and/or obligation) without entry by the Court of an appropriate confidentiality order. Pending entry of such an order, Alcoa will produce confidential

information to plaintiff pursuant to Local Rule 26.2 of the District of Delaware.

9. Alcoa objects to the Document Requests insofar as they assume disputed facts or legal conclusions in defining the documents requested. Alcoa hereby denies any such disputed facts or legal conclusions to the extent assumed by each document request. Any response or objection, including any production of documents, by Alcoa with respect to any such document request is without prejudice to this objection.

10. Alcoa's objections and responses to the Document Requests, including any production of documents, are not intended to waive or prejudice any objections Alcoa may assert now or in the future, including, without limitation, objections as to the relevance of the subject matter of any document request, or of the admissibility of any response or document, or category of responses or documents, at trial. Alcoa expressly reserves any and all rights and privileges under the Federal Rules of Civil Procedure, the Federal Rules of Evidence and any other law or rule, and the failure to assert such rights and privileges or the inadvertent disclosure by Alcoa of information protected by such rights or privileges shall not constitute a waiver thereof, either with respect to these

responses or with respect to any future discovery responses or objections.

Specific Objections and Responses

In addition to the foregoing General Objections, which apply to each document request as if set forth fully with each specific objection and response below, Alcoa makes the following Specific Objections and Responses:

Document Request No. 1

All documents identified in Defendant's Initial Disclosure.

Response to Document Request No. 1

Alcoa incorporates its General Objections into its response to Document Request No. 1. Subject to and without waiving the foregoing objections, Alcoa will perform a reasonable search for the documents identified in Alcoa's Initial Disclosure, and will produce to plaintiff, or make available to plaintiff for inspection and copying, any such non-privileged documents Alcoa finds.

Document Request No. 2

All documents that relate to the '639 patent, including without limitation:

(a) all documents that relate to any lawsuits relating to the '639 patent, or any of its foreign counterpart patents or applications;

(b) all documents that relate to the preparation, filing, prosecution, or issuance of the '639 patent,

including without limitation Defendant's internal patent files, all prior art contained in those files or otherwise studied, considered, or referenced in connection with said matters, and any application and amendment, including without limitation drafts thereof, associated with the '639 patent;

(c) all documents that relate to the preparation, filing, prosecution, issuance, scope, validity, infringement, or enforceability of any foreign or United States patent or patent application based upon or claiming priority from the '639 patent or any application associated with the '639 patent, including without limitation Defendant's internal patent files, all prior art contained in those files or otherwise studied, considered, or referenced in connection with said matters, and any application or amendment, including without limitation drafts thereof,

(d) all documents that relate to the ownership, assignment, publication, notification, enforcement, or licensing of the '639 patent, or any of its foreign counterpart patents or applications;

(e) all documents that relate to any searches regarding the scope, validity, patentability, or enforceability of the '639 patent, or any of its foreign counterpart patents or applications, and all prior art references located by such searches;

(f) all documents that relate to any opinions regarding the scope, validity, patentability, or enforceability of the '639 patent, or any of its foreign counterpart patents or applications, and all prior art references mentioned or considered in connection therewith;

(g) all documents that relate to any communication concerning the validity or possible invalidity of the '639 patent, the enforceability or possible nonenforceability of the '639 patent, the infringement, noninfringement or possible infringement or noninfringement of the '639 patent by any aluminum alloy or alloy product or method for producing any aluminum alloy or alloy product, or any intention or possible intention to enforce the '639 patent, including without limitation communications with Airbus or Boeing;

(h) all documents that relate to any comparison between the whole or any part of the subject matter, disclosure, or claims of the '639 patent, or any of its foreign counterpart patents or applications, and any aluminum alloy or alloy product;

(i) all documents that relate to any comparison between the whole or any part of the subject matter, disclosure, or claims of the '639 patent, or any of its foreign counterpart patents or applications, and any method for producing aluminum alloy or alloy product;

(j) all documents that relate to any testing, research and development, or study performed by or on behalf of Defendant with respect to the subject matter or [sic] any claim of the '639 patent, or any of its foreign counterpart patents or applications; and

(k) all documents that relate to the marking or non-marking of any aluminum alloy or alloy product as covered by the '639 patent.

Response to Document Request No. 2

Alcoa incorporates its General Objections into its response to Document Request No. 2, with particular reference to paragraph 1 of its General Objections. Alcoa further objects to subpart 2(j) on the grounds and to the extent that it seeks information not relevant to the subject matter of the pending action and not reasonably calculated to lead to the discovery of admissible evidence, insofar as it seeks documents generated or produced subsequent to March 6, 1992, the filing date of Application No. 847,352 for the '639 patent. Subject to and without waiving the foregoing objections, Alcoa will perform a reasonable search for the following documents: (1) documents responsive to subparts 2(a)-(i) and 2(k); and (2) documents responsive to subpart

2(j), to the extent those documents were generated or produced on or before March 6, 1992. Alcoa will produce to plaintiff, or make available to plaintiff for inspection and copying, any such non-privileged documents Alcoa finds.

Document Request No. 3

All documents that relate to any of the tests, measurements, examples, or property values referred to in the '639 patent, any application associated with the '639 patent, or any of the foreign counterpart patents or applications of the '639 patent.

Response to Document Request No. 3

Alcoa incorporates its General Objections into its response to Document Request No. 3. Alcoa further objects to Document Request No. 3 on the grounds and to the extent that it seeks information that is not relevant to the subject matter involved in the pending action and not reasonably calculated to lead to the discovery of admissible evidence, insofar as it purports to require Alcoa to produce documents generated or prepared subsequent to March 6, 1992, the filing date of Application No. 847,352 for the '639 patent. Subject to and without waiving the foregoing objections, Alcoa will perform a reasonable search for those documents responsive to Document Request No. 3 which were generated or prepared on or before March 6, 1992, and will produce to plaintiff, or make available to plaintiff for inspection and copying, any such non-privileged documents Alcoa finds.

Document Request No. 4

All documents that relate to any testing procedure, including without limitation any standard promulgated by the American Society of Testing and Materials, referred to in the '639 patent, any application associated with the '639 patent, or any of the foreign counterpart patents or applications of the '639 patent.

Response to Document Request No. 4

Alcoa incorporates its General Objections into its response to Document Request No. 4. Alcoa further objects to Document Request No. 4 on the grounds and to the extent that it seeks information that is not relevant to the subject matter involved in the pending action and not reasonably calculated to lead to the discovery of admissible evidence, insofar as it purports to require Alcoa to produce documents generated or prepared subsequent to March 6, 1992, the filing date of Application No. 847,352 for the '639 patent. Subject to and without waiving the foregoing objections, Alcoa will perform a reasonable search for those documents responsive to Document Request No. 4 which describe the testing procedures or standards "referred to in the '639 patent, any application associated with the '639 patent, or any of the foreign counterpart patents or applications", or, to the extent such documents were produced or generated on or before March 6, 1992, which concern any testing procedure or standard relating to the research and development of the invention disclosed in the

'639 patent. Alcoa will produce to plaintiff, or make available to plaintiff for inspection and copying, any such non-privileged documents Alcoa finds.

Document Request No. 5

All documents that relate to 2524 aluminum alloy or alloy product, including without limitation:

(a) all documents that relate to the composition, properties, or physical characteristics of 2524 aluminum alloy or alloy product;

(b) all documents that relate to the production or manufacture of 2524 aluminum alloy or alloy product;

(c) all documents that relate to any standard or specification, whether internal or public, relating to the composition, properties, or method for producing 2524 aluminum alloy or alloy product;

(d) all documents that relate to the development or design of 2524 aluminum alloy or alloy product;

(e) all documents that relate to any study, investigation, analysis, or test of 2524 aluminum alloy or alloy product;

(f) all documents that relate to qualification of 2524 aluminum alloy or alloy product for use by or on behalf of an aircraft manufacturer;

(g) all documents that relate to the marketing, purchase, or sale of 2524 aluminum alloy or alloy product, including without limitation fact sheets and green letters (the production of routine transactional documents that contain no information concerning the composition, properties, test results or specifications of 2524 aluminum alloy or alloy products may be deferred if a description is provided of the volume, location and time period covered for each category of such documents); and

(h) all documents that relate to any communication relating to 2524 aluminum alloy or alloy product.

Response to Document Request No. 5

Alcoa incorporates its General Objections into its response to Document Request No. 5, with particular reference to paragraph 1 of its General Objections as it relates to subpart 5(h). Alcoa further objects to subparts 5(a)-(e) on the grounds and to the extent that those subparts seek information that is not relevant to the subject matter involved in the pending action and not reasonably calculated to lead to the discovery of admissible evidence, insofar as they purport to require Alcoa to produce documents generated or prepared subsequent to March 6, 1992, the filing date of Application No. 847,352 for the '639 patent. Alcoa further objects to subpart 5(h) on those same grounds, insofar as it purports to require Alcoa to produce documents generated or prepared subsequent to March 6, 1992, other than to the extent such documents relate to communications concerning the marketing, purchase or sale of 2524 aluminum alloy products. Alcoa further objects to subpart 5(h) because it is overbroad and unduly burdensome. Subject to and without waiving the foregoing objections, Alcoa will perform a reasonable search for the following documents: (1) any documents responsive to subparts 5(a)-5(e), to the extent such documents were generated on or prior to March 6, 1992; (2) any documents responsive to subparts 5(f) and 5(g); and (3) any documents responsive to

subpart 5(h), to the extent such documents either were generated on or prior to March 6, 1992, or relate to the marketing, purchase, or sale of 2524 aluminum alloy products (without limitation as to time). Alcoa will produce to plaintiff, or make available to plaintiff for inspection and copying, any such non-privileged documents Alcoa finds.

Document Request No. 6

All documents that relate to any conception, reduction to practice, or embodiment of any invention described or claimed in the '639 patent, including without limitation:

(a) all documents that relate to the composition, properties, or physical characteristics of any conception, reduction to practice, or embodiment of any invention described or claimed in the '639 patent;

(b) all documents that relate to the production or manufacture of any conception, reduction to practice, or embodiment of any invention described or claimed in the '639 patent;

(c) all documents that relate to any standard or specification, whether internal or public, relating to the composition, properties, or method for producing any conception, reduction to practice, or embodiment of any invention described or claimed in the '639 patent;

(d) all documents that relate to the development or design of any conception, reduction to practice, or embodiment of any invention described or claimed in the '639 patent;

(e) all documents that relate to any study, investigation, analysis, or test of any conception, reduction to practice, or embodiment of any invention described or claimed in the '639 patent;

(f) all documents that relate to qualification of any conception, reduction to practice, or embodiment of any invention described or claimed in the '639 patent for use by or on behalf of an aircraft manufacturer;

(g) all documents that relate to the marketing, purchase, or sale of any conception, reduction to practice, or embodiment of any invention described or claimed in the '639 patent; and

(h) all documents that relate to any communication relating to any conception, reduction to practice, or embodiment of any invention described or claimed in the '639 patent.

Response to Document Request No. 6

Alcoa incorporates its General Objections into its response to Document Request No. 6, with particular reference to paragraph 1 of its General Objections as it relates to subpart 6(h). Alcoa further objects to subparts 6(d) and 6(e) because they are vague and ambiguous as to the terms "development or design of any conception" and "study, investigation, analysis, or test of any conception". Alcoa further objects to subparts 6(a)-(e) on the grounds and to the extent that those subparts seek information that is not relevant to the subject matter involved in the pending action and not reasonably calculated to lead to the discovery of admissible evidence, insofar as they purport to require Alcoa to produce documents generated or prepared subsequent to March 6, 1992, the filing date of Application No. 847,352 for the '639 patent. Alcoa further objects to subpart 6(h) on those same grounds, insofar as it purports to require Alcoa to produce documents generated or prepared subsequent to March 6, 1992, other than to the extent such documents relate to communications concerning the marketing,

purchase or sale of 2524 aluminum alloy products (the aluminum alloy products marketed by Alcoa that fall within the scope of the '639 patent). Alcoa further objects to subpart 6(h) because it is overbroad and unduly burdensome. Subject to and without waiving the foregoing objections, Alcoa will perform a reasonable search for the following documents: (1) any documents responsive to subparts 6(a)-6(e), to the extent those documents were generated on or prior to March 6, 1992; (2) any documents responsive to subparts 6(f) and 6(g); and (3) any documents responsive to subpart 6(h), to the extent such documents either were generated on or prior to March 6, 1992, or relate to the marketing, purchase, or sale of 2524 aluminum alloy products (without limitation as to time). Alcoa will produce to plaintiff, or make available to plaintiff for inspection and copying, any such non-privileged documents Alcoa finds.

Document Request No. 7

All documents that relate to 2024A aluminum alloy or alloy product, including without limitation:

(a) all documents that relate to the composition, properties, or physical characteristics of 2024A aluminum alloy or alloy product;

(b) all documents that relate to the production or manufacture of 2024A aluminum alloy or alloy product;

(c) all documents that relate to any standard or specification, whether internal or public, relating to the composition, properties, or method for producing 2024A aluminum alloy or alloy product;

(d) all documents that relate to the development or design of 2024A aluminum alloy or alloy product;

(e) all documents that relate to any study, investigation, analysis, or test of 2024A aluminum alloy or alloy product;

(f) all documents that relate to qualification of 2024A aluminum alloy or alloy product for use by or on behalf of an aircraft manufacturer;

(g) all documents that relate to the marketing, purchase, or sale of 2024A aluminum alloy or alloy product;

(h) all documents that relate to any communication relating to 2024A aluminum alloy or alloy product; and

(i) all documents related to Defendant's knowledge relating to the composition, properties, or method for producing 2024A aluminum alloy or alloy product.

Response to Document Request No. 7

Alcoa incorporates its General Objections into its response to Document Request No. 7. Subject to and without waiving the foregoing objections, Alcoa will perform a reasonable search for documents responsive to Document Request No. 7, and will produce to plaintiff, or make available to plaintiff for inspection and copying, any such non-privileged documents Alcoa finds.

Document Request No. 8.

All documents that relate to the use of a reheating step between stages of hot working in the production of any aluminum alloy product, including without limitation:

(a) all documents that relate to the composition, properties, or physical characteristics of any aluminum alloy product made, in whole or in part, by use of a reheating step between stages of hot working;

(b) all documents that relate to the production or manufacture of aluminum alloy product using a reheating step between stages of hot working;

(c) all documents that relate to any study, investigation, analysis, or test relating to the damage tolerance of an aluminum alloy product made, in whole or in part, by use of a reheating step between stages of hot working; and

(d) all documents relating to the effect or possible effect of a reheating step between stages of hot working on the damage tolerance of an aluminum alloy product made, in whole or in part, by use of such a reheating step.

Response to Document Request No. 8

Alcoa incorporates its General Objections into its response to Document Request No. 8. Alcoa further objects to Document Request No. 8 because it is vague and ambiguous as to the term "reheating step". Alcoa interprets "reheating step" as referring to the reheating step disclosed in the '639 patent. Alcoa further objects to Document Request No. 8 on the grounds and to the extent that it seeks information that is not relevant to the subject matter of the pending action and not reasonably calculated to lead to the discovery of admissible evidence, insofar as

it purports to require Alcoa to produce documents generated or prepared subsequent to March 6, 1992, the filing date of Application No. 847,352 for the '639 patent, and insofar as it purports to require Alcoa to produce documents concerning undefined "reheating steps" different from that process disclosed in the '639 patent. Subject to and without waiving the foregoing objections, Alcoa will perform a reasonable search for those documents responsive to Document Request No. 8 which were generated or produced on or before March 6, 1992, and which relate to the use of a "reheating step" within the parameters disclosed by the '639 patent. Alcoa will produce to plaintiff, or make available to plaintiff for inspection and copying, any such non-privileged documents Alcoa finds.

Document Request No. 9

All documents that relate to the use of a reheat furnace in the production of any aluminum alloy product, including without limitation:

(a) all documents that relate to the composition, properties, or physical characteristics of any aluminum alloy product made, in whole or in part, with a reheat furnace;

(b) all documents that relate to the production or manufacture of aluminum alloy product using a reheat furnace;

(c) all documents that relate to any study, investigation, analysis, or test relating to the damage tolerance of an aluminum alloy product made, in whole or in part, with a reheat furnace; and

(d) all documents relating to the effect or possible effect of the use of reheat furnace on the damage tolerance of an aluminum alloy product made, in whole or in part, by use of such a reheat furnace.

Response to Document Request No. 9

Alcoa incorporates its General Objections into its response to Document Request No. 9. Alcoa further objects to Document Request No. 9 because it is cumulative and duplicative of Document Request No. 8. Alcoa further objects to Document Request No. 9 on the grounds and to the extent that it seeks information that is not relevant to the subject matter of the pending action and not reasonably calculated to lead to the discovery of admissible evidence, insofar as it purports to require Alcoa to produce documents generated or prepared subsequent to March 6, 1992, the filing date of Application No. 847,352 for the '639 patent, and insofar as it purports to require Alcoa to produce documents concerning undefined "use[s] of a reheat furnace" in situations other than in which such reheat furnace is used as part of the reheating step as disclosed in the '639 patent. Subject to and without waiving the foregoing objections, Alcoa will perform a reasonable search for those documents Responsive to Document Request No. 9 which were generated or produced on or before March 6, 1992, and which concern the use of a reheat furnace during a reheating step within the parameters disclosed by the '639 patent. Alcoa will produce to plaintiff, or make available to plaintiff

for inspection and copying, any such non-privileged documents Alcoa finds.

Document Request No. 10

All documents that relate to the use of an intermediate thermomechanical treatment, including without limitation intermediate reheating, to improve the strength or damage tolerance of any aluminum alloy or alloy product, including without limitation:

(a) all documents that relate to the composition, properties, or physical characteristics of any aluminum alloy product made, in whole or in part, by use of an intermediate thermomechanical treatment, including without limitation intermediate reheating;

(b) all documents that relate to the production or manufacture of aluminum alloy product using an intermediate thermomechanical treatment, including without limitation intermediate reheating;

(c) all documents that relate to any study, investigation, analysis, or test relating to the damage tolerance of an aluminum alloy product made, in whole or in part, by use of an intermediate thermomechanical treatment, including without limitation intermediate reheating; and

(d) all documents relating to the effect or possible effect of an intermediate thermomechanical treatment, including without limitation intermediate reheating, on the damage tolerance of an aluminum alloy product made, in whole or in part, by use of such an intermediate thermomechanical treatment.

Response to Document Request No. 10

Alcoa incorporates its General Objections into its response to Document Request No. 10. Alcoa further objects to Document Request No. 10 because it is cumulative and duplicative of Document Request Nos. 8 and 9. Alcoa further objects to Document Request No. 10 because it is vague and

ambiguous as to the term "intermediate thermomechanical treatment". Alcoa interprets "intermediate thermomechanical treatment" as referring to the reheating step disclosed in the '639 patent. Alcoa further objects to Document Request No. 10 on the grounds and to the extent that it seeks information that is not relevant to the subject matter of the pending action and not reasonably calculated to lead to the discovery of admissible evidence, insofar as it purports to require Alcoa to produce documents that were generated or prepared subsequent to March 6, 1992, the filing date of Application No. 847,352 for the '639 patent, and insofar as it purports to require Alcoa to produce documents concerning undefined "intermediate thermomechanical treatments" different from the reheating step disclosed in the '639 patent. Subject to and without waiving the foregoing objections, Alcoa will perform a reasonable search for those documents responsive to Document Request No. 10 which were generated or produced on or before March 6, 1992, and which concern the use of the reheating step within the parameters disclosed by the '639 patent. Alcoa will produce to plaintiff, or make available to plaintiff for inspection and copying, any such non-privileged documents Alcoa finds.

<u>Document Request No. 11</u>

All documents that relate to the damage tolerance of any 2xxx alloy or alloy product, including without limitation:

(a) all documents that relate to any standard or specification, whether internal or public, relating to the damage tolerance of any 2xxx aluminum alloy or alloy product;

(b) all documents that relate to any tests, studies, or measurements of the damage tolerance of any 2xxx aluminum alloy or alloy product;

(c) all documents that relate to typical, average, or estimated damage tolerance of any 2xxx aluminum alloy or alloy product;

(d) all documents that relate to minimum, maximum, guaranteed or guaranteeable, or statistical limits, including without limitation confidence limits, for damage tolerance of any 2xxx aluminum alloy or alloy product;

(e) all documents that relate to study or analysis of any relationship between composition, processing, or microstructure and damage tolerance of any 2xxx aluminum alloy or alloy product;

(f) all documents that relate to the marketing of any 2xxx aluminum alloy or alloy product relating to the damage tolerance of that alloy or alloy product, including without limitation fact sheets and green letters relating to damage tolerance; and

(g) all documents that relate to any communications between Alcoa and any third party relating to the damage tolerance of any 2xxx aluminum alloy or alloy product.

Response to Document Request No. 11

Alcoa incorporates its General Objections into its response to Document Request No. 11. Alcoa further objects to Document Request No. 11 because it is vague and ambiguous as to the term "damage tolerance". Alcoa further objects to Document Request No. 11 as overbroad and unduly burdensome, insofar as it purports to require Alcoa to produce documents relating to all aluminum alloys "having copper as the major

alloying element". There are more than fifty different 2xxx aluminum alloys registered with the Aluminum Association alone. Of the 2xxx series, the '639 patent refers only to 2024 alloy, and only with respect to the properties of fracture toughness, resistance to fatigue crack growth, strength, and corrosion resistance. Alcoa further objects to Document Request No. 11 on the grounds and to the extent that it seeks information that is not relevant to the subject matter of the pending action and not reasonably calculated to lead to the discovery of admissible evidence, insofar as it purports to require Alcoa to produce documents about alloys other than the 2524, 2024A, and 2024 alloys. Alcoa further objects to subparts 11(a)-(e) and (g) on those same grounds, insofar as they purport to require Alcoa to produce documents concerning the 2524 alloy that were generated or prepared subsequent to March 6, 1992, the filing date of Application No. 847,352 for the '639 patent, other than to the extent such documents relate to communications regarding the marketing, purchase or sale of 2524 aluminum alloy products. Subject to and without waiving the foregoing objections, Alcoa will perform a reasonable search for the following documents: (1) all documents concerning the "damage tolerance" properties of fracture toughness or resistance to fatigue crack growth relating to the inventions disclosed by the '639 patent, to

the extent those documents were generated on or before March 6, 1992; (2) any documents responsive to subparts 11(a)-11(g) relating to the 2024A alloy; (3) documents responsive to subparts 11(a)-(g) sufficient to show the typical "damage tolerance" properties of fracture toughness or resistance to fatigue crack growth of 2024 alloy at the time of the application for the '639 patent; (4) any documents responsive to subparts 11(a)-(e), to the extent those documents were generated on or before March 6, 1992, and relate to any properties of the 2524 alloy (the alloy marketed by Alcoa that falls within the scope of the '639 patent); (5) any documents responsive to subpart 11(f) relating to the 2524 alloy; and (6) any documents responsive to subpart 11(g), to the extent those documents concern the 2524 alloy, and either were generated on or before March 6, 1992, or relate to communications with third parties concerning the marketing, purchase, or sale of 2524 aluminum alloy products (without limitation as to time). Alcoa will produce to plaintiff, or make available to plaintiff for inspection and copying, any such non-privileged documents Alcoa finds.

<u>Document Request No. 12</u>

All documents that relate to any standard or specification, whether internal or public, relating to the damage tolerance of any 7xxx aluminum alloy or alloy product.

Response to Document Request No. 12

Alcoa incorporates its General Objections into its response to Document Request No. 12. Alcoa further objects to Document Request No. 12 on the grounds and to the extent that it seeks information that is not relevant to the subject matter of the pending action, and not reasonably calculated to lead to the discovery of admissible evidence, insofar as the '639 patent does not concern 7xxx aluminum alloys or alloy products, and insofar as the 2524, 2024A, and 2024 alloys are not 7xxx alloys. Alcoa further objects to Document Request No. 12 as overbroad and unduly burdensome, insofar as it purports to require Alcoa to produce documents relating to all aluminum alloys "having zinc as the major alloying element", there being more than sixty different 7xxx aluminum alloys registered with the Aluminum Association alone.

Document Request No. 13

All documents that relate to typical, average, or estimated damage tolerance of any 7xxx aluminum alloy or alloy product.

Response to Document Request No. 13

Alcoa incorporates its General Objections into its response to Document Request No. 13. Alcoa further objects to Document Request No. 13 on the grounds and to the extent that it seeks information that is not relevant to the subject matter of the pending action and not reasonably

calculated to lead to the discovery of admissible evidence, insofar as the '639 patent does not concern 7xxx aluminum alloys or alloy products, and insofar as the 2524, 2024A, and 2024 alloys are not 7xxx alloys. Alcoa further objects to Document Request No. 13 as overbroad and unduly burdensome, insofar as it purports to require Alcoa to produce documents relating to all aluminum alloys "having zinc as the major alloying element", there being more than sixty different 7xxx aluminum alloys registered with the Aluminum Association alone.

Document Request No. 14

All documents that relate to minimum, maximum, guaranteed or guaranteeable, or statistical limits, including without limitation confidence limits, for damage tolerance of any 7xxx aluminum alloy or alloy product.

Response to Document Request No. 14

Alcoa incorporates its General Objections into its response to Document Request No. 14. Alcoa further objects to Document Request No. 14 on the grounds and to the extent that it seeks information that is not relevant to the subject matter of the pending action and not reasonably calculated to lead to the discovery of admissible evidence, insofar as the '639 patent does not concern 7xxx aluminum alloys or alloy products, and insofar as the 2524, 2024A, and 2024 alloys are not 7xxx alloys. Alcoa further objects to Document Request No. 14 as overbroad and unduly

burdensome, insofar as it purports to require Alcoa to produce documents relating to all aluminum alloys "having zinc as the major alloying element", there being more than sixty different 7xxx aluminum alloys registered with the Aluminum Association alone.

Document Request No. 15

All documents that relate to study or analysis of any relationship between composition, processing, or microstructure and damage tolerance of any 7xxx aluminum alloy or alloy product.

Response to Document Request No. 15

Alcoa incorporates its General Objections into its response to Document Request No. 15. Alcoa further objects to Document Request No. 15 on the grounds and to the extent that it seeks information that is not relevant to the subject matter of the pending action and not reasonably calculated to lead to the discovery of admissible evidence, insofar as the '639 patent does not concern 7xxx aluminum alloys or alloy products, and insofar as the 2524, 2024A, and 2024 alloys are not 7xxx alloys. Alcoa further objects to Document Request No. 15 as overbroad and unduly burdensome, insofar as it purports to require Alcoa to produce documents relating to all aluminum alloys "having zinc as the major alloying element", there being more than sixty different 7xxx aluminum alloys registered with the Aluminum Association alone.

Document Request No. 16

All documents that relate to any program, investigation, or attempt, whether or [sic] successful or not, by Defendant or any other person to develop an aluminum alloy or alloy product having improved damage tolerance relative to standard 2024 aluminum alloy or alloy product, including without limitation:

(a) all documents that relate to the composition, properties, or method for producing an aluminum alloy or alloy product having improved damage tolerance relative to standard 2024 aluminum alloy or alloy product;

(b) all documents that relate to any study, investigation, analysis, or test of the feasibility of improving the damage tolerance of an aluminum alloy or alloy product relative to standard 2024 aluminum alloy or alloy product;

(c) all documents that relate to the estimation or identification of any opportunity to market or sell an aluminum alloy or alloy product having improved damage tolerance relative to standard 2024 aluminum alloy or alloy product, including without limitation all documents relating to communications between Alcoa and third parties;

(d) all documents that relate to any property goal and approach, including without limitation any preliminary or tentative property goal or approach, relating to an aluminum alloy or alloy product having improved damage tolerance relative to standard 2024 aluminum alloy or alloy product, including without limitation all documents relating to communications between Alcoa and third parties;

(e) all documents that relate to any business plan, including without limitation any preliminary, tentative, or detailed business plan, relating to an aluminum alloy or alloy product having improved damage tolerance relative to standard 2024 aluminum alloy or alloy product;

(f) all documents that relate to any production or fabrication, including laboratory production or fabrication, of an aluminum alloy or alloy product

having improved damage tolerance relative to standard 2024 aluminum alloy or alloy product;

(g) all documents that relate to any tests or measurements of the composition or properties of an aluminum alloy or alloy product having improved damage tolerance relative to standard 2024 aluminum alloy or alloy product;

(h) all documents that relate to any communication with third parties, including any customer feedback, relating to an aluminum alloy or alloy product having improved damage tolerance relative to standard 2024 aluminum alloy or alloy product, including without limitation communications concerning any desire by Boeing to develop a significantly improved aluminum alloy for aircraft fuselages;

(i) all documents that relate to the guaranteeability or statistical limits, including without limitation confidence limits, for the composition or properties of an aluminum alloy or alloy product having improved damage tolerance relative to standard 2024 aluminum alloy or alloy product; including without limitation all documents that relate to communications between Alcoa and third parties; and

(j) all documents that relate to commercial implementation or scale-up relating to an aluminum alloy or alloy product having improved damage tolerance relative to standard 2024 aluminum alloy or alloy product.

Response to Document Request No. 16

Alcoa incorporates its General Objections into its response to Document Request No. 16. Alcoa further objects to Document Request No. 16 because it is vague and ambiguous as to the terms "damage tolerance" and "standard 2024 aluminum alloy or alloy product". Alcoa further objects to Document Request No. 16 as incoherent, in that the subparts do not appear to fall within the scope of the general

request. Alcoa interprets the request to be limited to documents "that relate to any program, investigation, or attempt, whether successful or not, by Defendant or any other person, to develop an aluminum alloy or alloy product having improved damage tolerance" properties relative to the typical fracture toughness and resistance to fatigue crack growth properties of 2024 alloy at the time of the application for the '639 patent. Alcoa further objects to Document Request No. 16 on the grounds and to the extent that it seeks information that is not relevant to the subject matter of the pending action and not reasonably calculated to lead to the discovery of admissible evidence, insofar as it purports to require Alcoa to produce documents concerning alloys other than the 2524 alloy (the alloy marketed by Alcoa that falls within the scope of the '639 patent) or the 2024A alloy. Alcoa further objects to subparts 16(a), (b), (f), (g), and (j) on those same grounds, insofar as they purport to require Alcoa to produce documents concerning the 2524 alloy that were generated or prepared subsequent to March 6, 1992, the filing date of Application No. 847,352 for the '639 patent. Alcoa further objects to subparts 16(c), (d), (h) and (i) on those same grounds, insofar as they purport to require Alcoa to produce documents concerning the 2524 alloy that were generated subsequent to March 6, 1992, the filing date of Application

No. 847,352 for the '639 patent, except to the extent such documents relate to communications with third parties concerning the marketing, purchase, or sale of 2524 aluminum alloy products. Subject to and without waiving the foregoing objections, Alcoa will perform a reasonable search for the following documents: (1) any documents responsive to subparts 16(a), (b), (f), (g), and (j), to the extent those documents were generated on or before March 6, 1992, and concern the 2524 alloy; (2) any documents responsive to subparts 16(c), (d), (h), and (i), to the extent those documents concern the 2524 alloy, and either were generated on or before March 6, 1992, or relate to communications with third parties concerning the marketing, purchase, or sale of 2524 aluminum alloy products (without limitation as to time); (3) any documents responsive to subparts 16(e), to the extent those documents concern the 2524 alloy; and (4) any documents responsive to Document Request No. 16, to the extent those documents relate to the 2024A alloy. Alcoa will produce to plaintiff, or make available to plaintiff for inspection and copying, any such non-privileged documents Alcoa finds.

Document Request No. 17

All documents that relate to any data bank or historical data bank, relating to the strength, composition, or properties of aluminum alloy or alloy product.

Response to Document Request No. 17

Alcoa incorporates its General Objections into its response to Document Request No. 17. Alcoa further objects to Document Request No. 17 because it is vague and ambiguous as to the term "data bank or historical data bank". Alcoa further objects to Document Request No. 17 on the grounds and to the extent that it seeks information that is not relevant to the subject matter of the pending action and not reasonably calculated to lead to the discovery of admissible evidence, insofar as it purports to require Alcoa to produce documents about alloys other than the 2524 alloy (the alloy marketed by Alcoa that falls within the scope of the '639 patent) or the 2024A alloy, or other than as sufficient to show the typical strength, composition or properties of 2024 alloy at the time of the application for the '639 patent. Alcoa further objects to Document Request No. 17 on those same grounds, insofar as it purports to require Alcoa to produce documents concerning the 2524 alloy that were generated or prepared subsequent to March 6, 1992, the filing date of Application No. 847,352 for the '639 patent. Subject to and without waiving the foregoing objections, Alcoa will perform a reasonable search for the following documents: (1) any documents responsive to Document Request No. 17, to the extent those documents were generated or produced on or before March 6, 1992, and concern the 2524

alloy; (2) any documents responsive to Document Request No. 17, to the extent those documents concern the 2024A alloy; and (3) documents Responsive to Document Request No. 17 sufficient to show the typical strength, composition and properties of the 2024 alloy at the time of the application for the '639 patent. Alcoa will produce to plaintiff, or make available to plaintiff for inspection and copying, any such non-privileged documents Alcoa finds.

Document Request No. 18

All documents that relate to the use of statistical quality control or statistical process control in the production of aluminum alloy or alloy product, including without limitation all documents relating to the use of statistical quality control to improve the strength or damage tolerance of any aluminum alloy or alloy product or to reduce the variability of the strength or damage tolerance of any aluminum alloy or alloy product.

Response to Document Request No. 18

Alcoa incorporates its General Objections into its response to Document Request No. 18. Alcoa further objects to Document Request No. 18 because it is vague and ambiguous as to the term "use of statistical quality control or statistical process control". Alcoa further objects to Document Request No. 18 on the grounds and to the extent that it seeks information that is not relevant to the subject matter of the pending action and not reasonably calculated to lead to the discovery of admissible evidence, insofar as it purports to require Alcoa to produce documents

about alloys other than the 2524 or 2024A alloys. Alcoa further objects to Document Request No. 18 on those same grounds, insofar as it purports to require Alcoa to produce documents concerning the 2524 alloy that were generated or prepared subsequent to March 6, 1992, the filing date of Application No. 847,352 for the '639 patent. Alcoa further objects to Document Request No. 18 as overbroad and unduly burdensome, in that it contains no restriction by alloy or alloy product, or by place or date.

Document Request No. 19

All documents that relate to testing or measuring damage tolerance in any metal or metal product, including without limitation:

(a) all documents that relate to any method, procedure, standard, or specification, whether internal or public, for testing or measuring damage tolerance;

(b) all documents that relate to any study, analysis, investigation, or test of the significance or effect of specimen shape, size, width, length, or thickness on testing or measuring damage tolerance;

(c) all documents that relate to any study, analysis, investigation, or test of the significance or effect of crack length or position on testing or measuring damage tolerance;

(d) all documents that relate to any study, analysis, investigation, or test of the significance or effect of loading conditions on testing or measuring damage tolerance;

(e) all documents that relate to any study, analysis, investigation, or test of the significance or effect of relative humidity on testing or measuring damage tolerance;

(f) all documents that relate to any study, analysis, investigation, or test of the repeatability, reproducibility, accuracy, or experimental scatter relating to testing or measuring damage tolerance;

(g) all documents that relate to any study, analysis, investigation, or test of the guaranteeability of damage tolerance relating to the testing or measuring of damage tolerance, including but not limited to the use of confidence or other statistical limits with regard to specifications for any aluminum alloy or alloy product;

(h) all documents that relate to the use of tests or measurements of damage tolerance in the design of aircraft or aircraft components; and

(i) all documents that relate to communications with third parties relating to testing or measuring damage tolerance.

Response to Document Request No. 19

Alcoa incorporates its General Objections into its response to Document Request No. 19. Alcoa further objects to Document Request No. 19 because it is vague and ambiguous as to the term "damage tolerance". Alcoa further objects to Document Request No. 19 on the grounds and to the extent that it seeks information that is not relevant to the subject matter of the pending action and not reasonably calculated to lead to the discovery of admissible evidence, insofar as it purports to require Alcoa to produce documents about alloys other than the 2524 alloy (the alloy marketed by Alcoa that falls within the scope of the '639 patent), the 2024 alloy, or the 2024A alloy, and insofar as it purports to require Alcoa to produce documents concerning

the 2524 alloy that were generated or prepared subsequent to March 6, 1992, the filing date of Application No. 847,352 for the '639 patent (except to the extent that subpart 19(i) relates to communications with third parties concerning the marketing, purchase, or sale of 2524 aluminum alloy products). Alcoa further objects to Document Request No. 19 on those same grounds, insofar as it purports to require Alcoa to produce documents concerning the 2024 alloy other than documents sufficient to show the typical "damage tolerance" properties of the 2024 alloy, and the testing or measurement of such properties, at the time of the application for the '639 patent. Subject to and without waiving the foregoing objections, Alcoa will perform a reasonable search for the following documents: (1) any documents responsive to subparts 19(a)-19(i), to the extent those documents concern the 2524 alloy, and either were generated or produced on or before March 6, 1992, or relate to communications with third parties concerning the marketing, purchase, or sale of 2524 aluminum alloy products (without limitation as to time); (2) any documents responsive to Document Request No. 19, to the extent those documents concern the 2024A alloys; and (3) documents responsive to Document Request No. 19 sufficient to show the typical "damage tolerance" properties of 2024, and the testing or measurement of such properties, at the time of

the application for the '639 patent. Alcoa will produce to plaintiff, or make available to plaintiff for inspection and copying, any such non-privileged documents Alcoa finds.

Document Request No. 20

All documents related to any version of ASTM B646, ASTM E399, ASTM E561, or ASTM E647, including without limitation:

(a) all documents that relate to methods or procedures for tests or measurements conducted pursuant to any version of ASTM B646, ASTM E399, ASTM E561, or ASTM E647;

(b) all documents that relate to any comparison of test or measurement procedures with those prescribed by any version of ASTM B646, ASTM E399, ASTM E561, or ASTM E647;

(c) all documents that relate to the repeatability, reproducibility, accuracy or experimental scatter relating to tests or measurements conducted pursuant to any version of ASTM B646, ASTM E399, ASTM E561, or ASTM E647; and

(d) all documents that relate to communications, including without limitation all communications with the American Society of Testing and Materials or its members, relating to the formulation, drafting, content, adoption, or revision of any version of ASTM B646, ASTM E399, ASTM E561, or ASTM E647.

Response to Document Request No. 20

Alcoa incorporates its General Objections into its response to Document Request No. 20. The ASTM standards are publicly available documents equally accessible to Pechiney. Alcoa further objects to Document Request No. 20 as overbroad and unduly burdensome. Alcoa further objects to Document Request No. 20 on the grounds and to the extent

that it seeks information that is not relevant to the subject matter of the pending action and not reasonably calculated to lead to the discovery of admissible evidence, insofar as it purports to require Alcoa to produce documents about alloys other than the 2524 alloy (the alloy marketed by Alcoa that falls within the scope of the '639 patent), the 2024A alloy, or the 2024 alloy at the time of the application of the patent, and insofar as it purports to require Alcoa to produce documents concerning the 2524 alloy that were generated or prepared subsequent to March 6, 1992, the filing date of Application No. 847,352 for the '639 patent. Subject to and without waiving the foregoing objections, Alcoa will perform a reasonable search for the following documents: (1) any documents responsive to Document Request No. 20, to the extent those documents were generated or produced on or before March 6, 1992, and concern the 2524 alloy; (2) any documents responsive to Document Request No. 20, to the extent those document relate to the 2024 alloy at the time of the application for the patent; (3) any documents responsive to Document Request No. 20, to the extent those documents concern the 2024A alloy; and (4) any documents responsive to Document Request No. 20, to the extent those documents describe the testing standards referred to in the '639 patent. Alcoa will produce to

plaintiff, or make available to plaintiff for inspection and copying, any such non-privileged documents Alcoa finds.

Document Request No. 21

All documents related to Westmoreland Mechanical Testing & Research, Inc. and damage tolerance of any aluminum alloy or alloy product, including without limitation:

(a) all documents related to any agreement or communication between Alcoa and Westmoreland Mechanical Testing & Research, Inc. relating, in whole or part, to damage tolerance of any aluminum alloy or alloy product;

(b) all documents related to tests and measurements conducted by Westmoreland Mechanical Testing & Research, Inc. relating, in whole or in part, to damage tolerance of any aluminum alloy or alloy product; and

(c) all documents related to any study, analysis, investigation, or project conducted by Westmoreland Mechanical Testing & Research, Inc. relating, in whole or in part, to damage tolerance of any aluminum alloy or alloy product.

Response to Document Request No. 21

Alcoa incorporates its General Objections into its response to Document Request No. 21. Alcoa further objects to Document Request No. 21 because it is vague and ambiguous as to the "damage tolerance". Alcoa further objects to Document Request No. 21 on the grounds and to the extent that it seeks information that is not relevant to the subject matter of the pending action and not reasonably calculated to lead to the discovery of admissible evidence, insofar as it purports to require Alcoa to produce documents

relating to the "damage tolerance" properties of any alloy other than the 2524 alloy (the alloy marketed by Alcoa that falls within the scope of the '639 patent), the 2024A alloy, or the 2024 alloy at the time of the application for the patent, and insofar as it purports to require Alcoa to produce documents concerning the 2524 alloy that were generated or prepared subsequent to March 6, 1992, the filing date of Application No. 847,352 for the '639 patent. Subject to and without waiving the foregoing objections, Alcoa will perform a reasonable search for the following documents: (1) any documents responsive to Document Request No. 21, to the extent those documents were generated or produced on or before March 6, 1992, and concern the 2524 alloy; (2) any documents responsive to Document Request No. 21, to the extent those documents concern the 2024 alloy at the time of the application for the patent; and (3) any documents responsive to Document Request No. 21, to the extent those documents concern the 2024A alloy. Alcoa will produce to plaintiff, or make available to plaintiff for inspection and copying, any such non-privileged documents Alcoa finds.

Document Request No. 22

All documents related to Fracture Toughness Associates and damage tolerance of any aluminum alloy or alloy product, including without limitation:

(a) all documents related to any agreement or communication between Alcoa and Fracture Toughness Associates relating, in whole or in part, to damage tolerance of any aluminum alloy or alloy product;

(b) all documents related to tests and measurements conducted by Fracture Toughness Associates relating, in whole or in part, to damage tolerance of any aluminum alloy or alloy product; and

(c) all documents related to any study, analysis, investigation, or project conducted by Fracture Toughness Associates relating, in whole or in part, to damage tolerance of any aluminum alloy or alloy product.

Response to Document Request No. 22

Alcoa incorporates its General Objections into its response to Document Request No. 22. Alcoa further objects to Document Request No. 22 because the term "damage tolerance" is vague and ambiguous. Alcoa further objects to Document Request No. 22 on the grounds and to the extent that it seeks information that is not relevant to the subject matter of the pending action and not reasonably calculated to lead to the discovery of admissible evidence, insofar as it purports to require Alcoa to produce documents relating to the "damage tolerance" properties of any alloy other than the 2524 alloy (the alloy marketed by Alcoa that falls within the scope of the '639 patent), the 2024A alloy, or the 2024 alloy at the time of the application for the

patent, and insofar as it purports to require Alcoa to produce documents concerning the 2524 alloy that were generated or prepared subsequent to March 6, 1992, the filing date of Application No. 847,352 for the '639 patent. Subject to and without waiving the foregoing objections, Alcoa will perform a reasonable search for the following documents: (1) any documents responsive to Document Request No. 22, to the extent those documents were generated or produced on or before March 6, 1992, and concern the 2524 alloy; (2) any documents responsive to Document Request No. 22, to the extent those documents concern the 2024 alloy at the time of the application for the patent; and (3) any documents responsive to Document Request No. 22, to the extent those documents concern the 2024A alloy. Alcoa will produce to plaintiff, or make available to plaintiff for inspection and copying, any such non-privileged documents Alcoa finds.

Document Request No. 23

Documents sufficient to describe the management structure and organization of Alcoa, Inc., the Alcoa Technical Center, and Alcoa Mill Products and to identify persons holding executive positions or positions relating to research, development, production, testing, or obtaining patents for 2xxx or 7xxx aluminum alloys or alloy products.

Response to Document Request No. 23

Alcoa incorporates its General Objections into its response to Document Request No. 23. Alcoa further objects

to Document Request No. 23 on the grounds and to the extent that it seeks information that is not relevant to the subject matter of the pending action and not reasonably calculated to lead to the discovery of admissible evidence, insofar as it purports to require Alcoa to produce documents relating to alloys other than the 2524 alloy (the alloy marketed by Alcoa that falls within the scope of the '639 patent), the 2024 alloy, or the 2024A alloy. Subject to and without waiving the foregoing objections, Alcoa will perform a reasonable search for documents sufficient to describe the management structure and organization of Alcoa, Inc., the Alcoa Technical Center, and Alcoa Mill Products, and Alcoa will produce to plaintiff, or make available to plaintiff for inspection and copying, any such non-privileged documents Alcoa finds.

Document Request No. 24

All documents in the files, whether active or archived, of Andrew Alexander, David W. Brownlee, Robert J. Bucci, Edward L. Colvin, Carl R. Lippert, William J. O'Rourke, Jocelyn I. Petit, Robert W. Westerlund, Paul E. Magnusen, Wes Wells, or Jim Staley, that relate to:

(a) the '639 patent, any application associated with the '639 patent, or any foreign counterpart patent or application associated with the '639 patent;

(b) 2524 aluminum alloy or alloy product;

(c) the strength or damage tolerance of any aluminum alloy or alloy product;

(d) the testing or measurement of damage tolerance;

(e) the guaranteeability, or use or possible use of statistical limits, including but not limited to confidence limits, for any property of aluminum alloy or alloy products;

(f) the significance or effect of the composition, processing, or microstructure of aluminum alloy or alloy product on its properties;

(g) any version of ASTM B646, ASTM E399, ASTM E561, or ASTM E647; and

(h) the use of a reheating furnace, reheating between stages of hot working, or intermediate thermomechanical treatments, including without limitation intermediate reheating, in the production of aluminum alloy or alloy product.

Response to Document Request No. 24

Alcoa incorporates its General Objections into its response to Document Request No. 24, with particular reference to paragraph 1 of its General Objections as it relates to subpart 24(a). Alcoa further objects to Document Request No. 24 because it is vague and ambiguous as to the terms "damage tolerance", "intermediate thermomechanical reheating", and "intermediate reheating". Alcoa interprets the terms "intermediate thermomechanical reheating" and "intermediate reheating" to refer to the reheating step as disclosed by the '639 patent. Alcoa further objects to Document Request No. 24 on the grounds and to the extent that it seeks information that is not relevant to the subject matter of the pending action and not reasonably calculated to lead to the discovery of admissible evidence, insofar as it purports to require Alcoa to produce documents

about alloys other than the 2524, 2024, and 2024A alloys, and insofar as it purports to require Alcoa to produce documents concerning the 2524 alloy that were generated or prepared subsequent to March 6, 1992, the filing date of Application No. 847,352 for the '639 patent. Subject to and without waiving the foregoing objections, Alcoa will perform a reasonable search for the following documents: (1) any documents responsive to Document Request No. 24, to the extent those documents concern the '639 patent or foreign counterparts, the 2024 alloy, or the 2024A alloy; and (2) any documents responsive to Document Request No. 24, to the extent those documents concern the 2524 alloy and were generated or produced on or before March 6, 1992. Alcoa will produce to plaintiff, or make available to plaintiff for inspection and copying, any such non-privileged documents Alcoa finds.

Document Request No. 25

All documents that relate to any declarations or affidavits, relating to aluminum alloy or alloy product, prepared, authored or signed by Andrew Alexander, David W. Brownlee, Robert J. Bucci, Edward L. Colvin, Carl R. Lippert, William J. O'Rourke, Jocelyn I. Petit, Robert W. Westerlund, Paul E. Magnusen, Wes Wells, Jim Staley, or any individual identified in Defendant's initial disclosure.

Response to Document Request No. 25

Alcoa incorporates its General Objections into its response to Document Request No. 25, with particular

reference to paragraph 1 of its General Objections. Alcoa further objects to Document Request No. 25 on the grounds and to the extent that it seeks information that is not relevant to the subject matter of the pending action and not reasonably calculated to lead to the discovery of admissible evidence, insofar as it purports to require Alcoa to produce documents about patents other than the '639 patent or foreign counterparts or alloys other than the 2524 alloy (the alloy marketed by Alcoa that falls within the scope of the '639 patent), the 2024 alloy at the time of the application for the '639 patent, and the 2024A alloy. Subject to and without waiving the foregoing objections, Alcoa will perform a reasonable search for documents responsive to Document Request No. 25, to the extent those documents concern the '639 patent or foreign counterparts, or the 2524 alloy, the 2024 alloy at the time of the application for the '639 patent, or the 2024A alloy. Alcoa will produce to plaintiff, or make available to plaintiff for inspection and copying, any such non-privileged documents Alcoa finds.

Document Request No. 26

All documents that relate to any submission or draft submission to any patent-granting authority, including without limitation the United States Patent and Trademark Office, relating to aluminum alloy or alloy product or to testing or measuring damage tolerance, prepared, authored, or signed by Robert J. Bucci, Edward L. Colvin, Jocelyn I. Petit, Robert W. Westerlund, Paul E. Magnusen, Wes Wells,

Jim Staley, or any individual identified in Defendant's initial disclosure.

Response to Document Request No. 26

Alcoa incorporates its General Objections into its response to Document Request No. 26, with particular reference to paragraph 1 of its General Objections. Alcoa further objects to Document Request No. 26 on the grounds and to the extent that it seeks information that is not relevant to the subject matter of the pending action and not reasonably calculated to lead to the discovery of admissible evidence, insofar as it purports to require Alcoa to produce documents about patents other than the '639 patent or foreign counterparts. Subject to and without waiving the foregoing objections, Alcoa will perform a reasonable search for documents responsive to Document Request No. 26, to the extent those documents concern the '639 patent or foreign counterparts. Alcoa will produce to plaintiff, or make available to plaintiff for inspection and copying, any such non-privileged documents Alcoa finds.

Document Request No. 27

All documents that relate to any submission or draft submission to any patent-granting authority, including without limitation the United States Patent and Trademark Office, relating to the damage tolerance of any aluminum alloy or alloy product, prepared, authored, or signed by Andrew Alexander, David W. Brownlee, Carl R. Lippert, and William J. O'Rourke.

Response to Document Request No. 27

Alcoa incorporates its General Objections into its response to Document Request No. 27, with particular reference to paragraph 1 of its General Objections. Alcoa further objects to Document Request No. 27 on the grounds and to the extent that it seeks information that is not relevant to the subject matter of the pending action and not reasonably calculated to lead to the discovery of admissible evidence, insofar as it purports to require Alcoa to produce documents about patents other than the '639 patent or foreign counterparts. Subject to and without waiving the foregoing objections, Alcoa will perform a reasonable search for the documents responsive to Document Request No. 27, to the extent those documents concern the '639 patent or its foreign counterparts. Alcoa will produce to plaintiff, or make available to plaintiff for inspection and copying, any such non-privileged documents Alcoa finds.

Document Request No. 28

All documents that relate to any deposition, relating to aluminum alloy or alloy product or to testing or measuring damage tolerance, of Andrew Alexander, David W. Brownlee, Robert J. Bucci, Edward L. Colvin, Carl R. Lippert, William J. O'Rourke, Jocelyn I. Petit, Robert W. Westerlund, Paul E. Magnusen, Wes Wells, Jim Staley, or any individual identified in Defendant's initial disclosure.

Response to Document Request No. 28

Alcoa incorporates its General Objections into its response to Document Request No. 28, with particular

reference to paragraph 1 of its General Objections. Alcoa further objects to Document Request No. 28 on the grounds and to the extent that it seeks information that is not relevant to the subject matter of the pending action and not reasonably calculated to lead to the discovery of admissible evidence, insofar as it purports to require Alcoa to produce documents about alloys other than the 2524 alloy (the alloy marketed by Alcoa that falls within the scope of the '639 patent), the 2024 alloy at the time of the application for the '639 patent, or the 2024A alloy. Subject to and without waiving the foregoing objections, Alcoa will perform a reasonable search for documents responsive to Document Request No. 28, to the extent those documents concern the 2524 alloy, the 2024 alloy at the time of the application for the '639 patent, or the 2024A alloy. Alcoa will produce to plaintiff, or make available to plaintiff for inspection and copying, any such non-privileged documents Alcoa finds.

Document Request No. 29

All documents that relate to the Airbus A340-500, A340-600, or A3xxx including without limitation:

(a) all documents that relate to the design, development, or construction of the A340-500, A340-600, or A3xxx; and

(b) all documents that relate to aluminum alloy or alloy product considered for, or used in, the A340-500, A340-600, or A3xxx.

Response to Document Request No. 29

Alcoa incorporates its General Objections into its response to Document Request No. 29. Alcoa further objects to Document Request No. 29 because it is vague and ambiguous as to the terms "A3xxx" and "considered for". Alcoa further objects to Document Request No. 29 on the grounds and to the extent that it seeks information that is not relevant to the subject matter of the pending action and not reasonably calculated to lead to the discovery of admissible evidence, insofar as it purports to require Alcoa to produce documents about alloys other than the 2524 or 2024A alloys. Subject to and without waiving the foregoing objections, Alcoa will perform a reasonable search for the following documents: (1) any documents responsive to Document Request No. 29(a); and (2) any documents responsive to Document Request No. 29(b), to the extent that they relate to the use of the 2524 or 2024A alloys in the A340-500, A340-600, or A3xx. Alcoa will produce to plaintiff, or make available to plaintiff for inspection and copying, any such non-privileged documents Alcoa finds.

Document Request No. 30

All documents that relate to any damage tolerance property, specification, or requirement relating to the Boeing 777 or 7J7, including without limitation:

(a) all documents that relate to the development, drafting, or adoption of any material specification relating to the Boeing 777 or 7J7 and damage tolerance; and

(b) all documents that relate to the damage tolerance of any aluminum alloy or alloy product considered for, or used in, the Boeing 777 or 7J7.

Response to Document Request No. 30

Alcoa incorporates its General Objections into its response to Document Request No. 30. Alcoa further objects to Document Request No. 30 because it is vague and ambiguous as to the terms "damage tolerance" and "considered for". Alcoa further objects to Document Request No. 30 on the grounds and to the extent that it seeks information that is not relevant to the subject matter of the pending action and not reasonably calculated to lead to the discovery of admissible evidence, insofar as it purports to require Alcoa to produce documents about alloys other than the 2524 or 2024A alloys. Subject to and without waiving the foregoing objections, Alcoa will perform a reasonable search for the following documents: (1) any documents responsive to Document Request No. 30(a); and (2) any documents responsive to Document Request No. 30(b), to the extent that they relate to the "damage tolerance" properties of fracture toughness or resistance to fatigue crack growth of 2524 or

2024A alloys used in the Boeing 777 or 7J7. Alcoa will produce to plaintiff, or make available to plaintiff for inspection and copying, any such non-privileged documents Alcoa finds.

Document Request No. 31

All documents that relate to any damage tolerance property, specification, or requirement relating to the design, development, or construction of any aircraft designed or developed since 1980, including without limitation:

(a) all documents that relate to the development, drafting, or adoption of any material specification relating to such aircraft and damage tolerance; and

(b) all documents that relate to the damage tolerance of any aluminum alloy or alloy product considered for, or used in, such aircraft.

Response to Document Request No. 31

Alcoa incorporates its General Objections into its response to Document Request No. 31. Alcoa further objects to Document Request No. 31 because it is cumulative and duplicative of Document Requests Nos. 29 and 30. Alcoa further objects to Document Request No. 31 because it is vague and ambiguous as to the term "damage tolerance". Alcoa further objects to Document Request No. 31 because it is overbroad and unduly burdensome. Alcoa further objects to Document Request No. 31 on the grounds and to the extent that it seeks information that is not relevant to the subject matter of the pending action and not reasonably calculated to lead to the discovery of admissible evidence,

insofar as it purports to require Alcoa to produce documents about alloys other than the 2524 or 2024A alloys. Subject to and without waiving the foregoing objections, Alcoa will perform a reasonable search for documents responsive to Document Request No. 31, to the extent those documents relate to the 2524 or 2024A alloys. Alcoa will produce to plaintiff, or make available to plaintiff for inspection and copying, any such non-privileged documents Alcoa finds.

Document Request No. 32

All documents that relate to any practice or policy relating to notice, enforcement, marking, or licensing of a patent.

Response to Document Request No. 32

Alcoa incorporates its General Objections into its response to Document Request No. 32. Alcoa further objects to Document Request No. 32 as overbroad and unduly burdensome. Alcoa further objects to Document Request No. 32 on the grounds and to the extent that it seeks information that is not relevant to the subject matter of the pending action and not reasonably calculated to lead to the discovery of admissible evidence, insofar as it purports to require Alcoa to produce documents that do not relate to the '639 patent. Subject to and without waiving the foregoing objections, Alcoa will perform a reasonable search for those documents responsive to Document Request No. 32 which relate to the '639 patent. Alcoa will produce to

plaintiff, or make available to plaintiff for inspection and copying, any such non-privileged documents Alcoa finds.

Document Request No. 33

All documents that relate to any comparison of the damage tolerance of any 2024 aluminum alloy or alloy product to that of any alloy or alloy product.

Response to Document Request No. 33

Alcoa incorporates its General Objections into its response to Document Request No. 33. Alcoa further objects to Document Request No. 33 because it is cumulative and duplicative of Document Requests No. 5, 7 and 16. Alcoa further objects to Document Request No. 33 on the grounds and to the extent that it seeks information that is not relevant to the subject matter of the pending action and not reasonably calculated to lead to the discovery of admissible evidence, insofar as it purports to require Alcoa to produce documents concerning a comparison between any 2024 alloy and any other aluminum alloy other than the 2524 alloy (the alloy marketed by Alcoa that falls within the scope of the '639 patent) or the 2024A alloy, and insofar as it purports to require Alcoa to produce documents concerning the 2524 alloy generated or prepared subsequent to March 6, 1992, the filing date of Application No. 847,352 for the '639 patent. Subject to and without waiving the foregoing objections, Alcoa will perform a reasonable search for the following documents: (1) any documents responsive to Document Request

No. 33, to the extent those documents were generated or produced on or before March 6, 1992, and concern a comparison of the properties of the 2524 and 2024 alloys; (2) any documents responsive to Document Request No. 33, to the extent those documents concerning a comparison of the properties of the 2024A and 2024 alloys. Alcoa will produce to plaintiff, or make available to plaintiff for inspection and copying, any such non-privileged documents Alcoa finds.

Document Request No. 34

All documents that relate to the preparation, filing, prosecution, issuance, notification, enforcement, or licensing of any patent or patent application describing or claiming an aluminum alloy, alloy product, or method for making aluminum alloy or alloy product, having improved damage tolerance.

Response to Document Request No. 34

Alcoa incorporates its General Objections into its response to Document Request No. 34. Alcoa further objects to Document Request No. 34 because it is cumulative and duplicative of Document Request No. 2. Alcoa further objects to Document Request No. 34 because it is vague and ambiguous as to the term "damage tolerance". Alcoa further objects to Document Request No. 34 on the grounds and to the extent that it seeks information that is not relevant to the subject matter of the pending action and not reasonably calculated to lead to the discovery of admissible evidence, insofar as it purports to require Alcoa to produce documents

relating to patents other than the '639 patent or its foreign counterparts. Subject to and without waiving the foregoing objections, Alcoa will perform a reasonable search for documents responsive to Document Request No. 34, to the extent those documents concern the '639 patent or its foreign counterparts. Alcoa will produce to plaintiff, or make available to plaintiff for inspection and copying, any such non-privileged documents Alcoa finds.

Document Request No. 35

All documents related to the qualification of any 2x24 aluminum alloy or alloy product for use by or on behalf of an aircraft manufacturer that relate in whole or in part to the composition, strength, or damage tolerance of any aluminum alloy or alloy product.

Response to Document Request No. 35

Alcoa incorporates its General Objections into its response to Document Request No. 35. Alcoa further objects to Document Request No. 35 because it is cumulative and duplicative of Document Requests Nos. 29-31. Alcoa further objects to Document Request No. 35 on the grounds and to the extent that it seeks information that is not relevant to the subject matter of the pending action and not reasonably calculated to lead to the discovery of admissible evidence, insofar as it purports to require Alcoa to produce documents relating to alloys other than the 2524 and 2024A alloys. Alcoa further objects to Document Request No. 35 as overbroad and unduly burdensome. Subject to and without

waiving the foregoing objections, Alcoa will perform a reasonable search for documents responsive to Document Request No. 35, to the extent those documents concern the 2524 or 2024A alloys. Alcoa will produce to plaintiff, or make available to plaintiff for inspection and copying, any such non-privileged documents Alcoa finds.

<u>Document Request No. 36</u>

All documents related to any standard or specification, whether internal or public, for the composition, properties, or processing of any 2xxx or 7xxx aluminum alloy or alloy product.

<u>Response to Document Request No. 36</u>

Alcoa incorporates its General Objections into its response to Document Request No. 36, with particular reference to paragraphs 2 and 7 of its General Objections. Alcoa further objects to Document Request No. 36 on the grounds and to the extent that it seeks information that is not relevant to the subject matter of the pending action and not reasonably calculated to lead to the discovery of admissible evidence, insofar as it purports to require Alcoa to produce documents about alloys other than the 2524 alloy (the alloy marketed by Alcoa that falls within the scope of the '639 patent), the 2024 alloy at the time of the application for the '639 patent, and the 2024A alloy, and insofar as it purports to require Alcoa to produce documents concerning the 2524 alloy that were generated or prepared

subsequent to March 6, 1992, the filing date of Application No. 847,352 for the '639 patent. Subject to and without waiving the foregoing objections, Alcoa will perform a reasonable search for the following documents: (1) any document responsive to Document Request No. 36, to the extent those documents were generated or produced on or before March 6, 1992, and concern non-public standards or specifications regarding the 2524 alloy; (2) any document responsive to Document Request No. 36, to the extent those documents concern "public" standards or specifications regarding the 2524 alloy; and (3) any document responsive to Document Request No. 36, to the extent those documents concern the 2024A alloy, or the 2024 alloy at the time of the application for the '639 patent. Alcoa will produce to plaintiff, or make available to plaintiff for inspection and copying, any such non-privileged documents Alcoa finds.

Document Request No. 37

Documents sufficient to show Defendant's policy and practices relating to the retention, discarding, or destruction of documents of all forms.

Response to Document Request No. 37

Alcoa incorporates its General Objections into its response to Document Request No. 37. Subject to and without waiving the foregoing objections, Alcoa will perform a reasonable search for documents responsive to Document Request No. 37, and will produce to plaintiff, or make

available to plaintiff for inspection and copying, any such non-privileged documents Alcoa finds.

Document Request No. 38

All documents referred to, reviewed or relied upon in preparing responses to Plaintiff's Interrogatories.

Response to Document Request No. 38

Alcoa incorporates its General Objections into its response to Document Request No. 38. Alcoa further objects to Document Request No. 38 because, as of the date of the Request, plaintiff had not served any Interrogatories on Alcoa.

Document Request No. 39

All indexes, directories, and tables of contents for files or databases containing, in whole or in part, documents or information relating to the strength, composition or properties of 2xxx or 7xxx aluminum alloys or alloy products.

Response to Document Request No. 39

Alcoa incorporates its General Objections into its response to Document Request No. 39. Alcoa further objects to Document Request No. 39 because it is cumulative and duplicative of Document Request No. 17. Alcoa further objects to Document Request No. 39 on the grounds and to the extent that it seeks information that is not relevant to the subject matter of the pending action and not reasonably calculated to lead to the discovery of admissible evidence, insofar as it purports to require Alcoa to produce documents

about alloys other than the 2524 alloy (the alloy marketed by Alcoa that falls within the scope of the '639 patent), the 2024 alloy at the time of the application for the '639 patent, and the 2024A alloy, and insofar as it purports to require Alcoa to produce documents concerning the 2524 alloy that were generated or prepared subsequent to March 6, 1992, the filing date of Application No. 847,352 for the '639 patent. Subject to and without waiving the foregoing objections, Alcoa will perform a reasonable search for the following documents: (1) any document responsive to Document Request No. 39, to the extent those documents were generated or produced on or before March 6, 1992, and concern the 2524 alloy; and (2) any document responsive to Document Request No. 39, to the extent those documents concern the 2024 alloy at the time of the application for the '639 patent, or the 2024A alloy. Alcoa will produce to plaintiff, or make available to plaintiff for inspection and copying, any such non-privileged documents Alcoa finds.

Document Request No. 40

All documents related to the matters set forth in Defendant's document requests.

Response to Document Request No. 40

Alcoa incorporates its General Objections into its response to Document Request No. 40. Subject to and without waiving the foregoing objections, Alcoa will perform a

reasonable search for documents responsive to Document Request No. 40, and will produce to plaintiff, or make available to plaintiff for inspection and copying, any such non-privileged documents Alcoa finds.

Frederick L. Cottrell /dwb

R. Franklin Balotti (#679)
Frederick L. Cottrell, III (#2555)
Geoffrey S. Kercsmar (#3748)
RICHARDS, LAYTON & FINGER
One Rodney Square
P.O. Box 551
Wilmington, DE
(302) 658-6541

Attorneys for Defendant
Alcoa, Inc.

OF COUNSEL:

Evan R. Chesler
Daniel Slifkin
CRAVATH, SWAINE & MOORE
825 Eighth Avenue
New York, NY 10019
(212) 474-1000

Dated: July 12, 1999

CERTIFICATE OF SERVICE

It is hereby certified that true and correct copies of the foregoing were served this 12th day of July, 1999, on counsel as follows:

VIA FACSIMILE AND UNITED STATES EXPRESS MAIL

Joanne Ceballos, Esq.
Potter Anderson & Carroon LLP
Hercules Plaza
P.O. Box 951
Wilmington, DE 19899

William D. Iverson, Esq.
Covington & Burling
1201 Pennsylvania Avenue, N.W.
Washington, DC 20044-7566

David W. Balch

David W. Balch

Exhibit 12

IN THE UNITED STATES DISTRICT COURT
FOR THE DISTRICT OF DELAWARE

PECHINEY RHENALU, Plaintiff, v. ALCOA INC., Defendant.	Civil Action No. 99-301-SLR DECLARATION OF ROBERT W. WESTERLUND

STATE OF IOWA)
) ss.:
COUNTY OF SCOTT)

I, ROBERT W. WESTERLUND, declare as follows:

1. I am the Technical Advisor for Aerospace of Alcoa Mill Products, and one of the inventors of the methods and products disclosed in U.S. Patent No. 5,213,639, entitled Damage Tolerant Aluminum Alloy Products Useful For Aircraft Applications Such As Skin. Except where otherwise stated, I have personal knowledge of the facts stated below.

2524 Alloy

2. Alcoa Mill Products ("AMP") is a business unit of Alcoa Inc. At its Davenport Works in Iowa, AMP manufactures rolled aluminum products, as opposed to extruded or forged products, of both "thick" (plate) and "thin" (sheet) types. AMP makes alloys for both aerospace and non-aerospace applications.

3. Among other aerospace alloys, AMP makes 2524, an alloy which embodies certain of the inventions disclosed by the '639 patent. The 2524 alloy, however, also embodies certain trade secrets developed subsequent to the application for the '639 patent, which relate to properties other than damage tolerance. For instance, the current production process has modifications to the original process which were developed to address issues of surface appearance, as well as changes to reduce production costs.

<u>2x24 Aerospace Alloys in Dispute</u>

4. Alcoa's 2524 alloy and Pechiney's 2024A alloy have been registered with the Aluminum Association, which assigns the alloys their identifying numbers. Those numbers relate the alloys to prior registered alloys. Alcoa's 2524 alloy is listed as a modification of the 2024 alloy, while Pechiney's 2024A alloy is listed as a variation of the same 2024 alloy. All three may properly be referred to as <u>2x24</u> alloys. According to their registered chemical composition limits, the 2524, 2024A, and 2024 alloys contain copper as the primary alloying element as well as significant amounts of magnesium and manganese (and varying amounts of impurities and incidental elements).

5. The 2024 alloy was developed in the 1930's and was first assigned the 2024 number by the Aluminum Association in 1954. For several decades, AMP and other aluminum

manufacturers have made the 2024 alloy, which has been the most widely used alloy for commercial fuselage applications.

6. Relative to the 2024 alloy, Alcoa's 2524 alloy exhibits substantial improvements in the damage tolerance properties of fracture toughness and resistance to fatigue crack growth. These are properties that aircraft manufacturers find desirable. Alcoa's 2524 alloy is now being used in place of 2024 on several advanced aircraft, including the Boeing 777, the Airbus A340-500/600, and the Canadair Global Express.

Pechiney's Requests for Documents Regarding 2524

7. I understand that Pechiney has requested the production of documents regarding Alcoa's 2524 alloy as it relates to the issues of infringement or validity of the '639 patent. The original application date for the two parent applications of the '639 patent was August 27, 1990. The continuation-in-part application for the '639 patent was filed on March 6, 1992.

8. I understand that Alcoa is producing documents regarding the invention, testing, and development of the inventions disclosed in the '693 patent and the 2524 alloy, prior to the March 6, 1992. I also understand that we are producing documents relating to the testing (other than production lot testing) and marketing of the 2524 alloy regardless of date. We are not, however, producing documents relating to the development of the 2524 alloy

subsequent to the date of the CIP application. Those developments were made at substantial expense, are highly commercially sensitive, and do not bear upon the inventions disclosed in the patent.

Pechiney's Requests for Documents Regarding Alloys Other Than 2524, 2024A, and 2024

9. I understand that Pechiney's First Set of Requests for Production goes beyond the 2x24 family of alloys and asks for proprietary information regarding alloys that are neither referred to in the '639 patent nor in the Complaint, including all other copper based (2xxx) aluminum alloys and every zinc-based (7xxx) alloy. The 2xxx and 7xxx alloys together represent almost the entire production of the Davenport Works for aerospace materials. There are more than one hundred and ten 2xxx and 7xxx alloys listed in the International Alloy Designations of the Aluminum Association. They include most of the alloys that are critical to Alcoa's aerospace business, as well as many alloys that have no aerospace applications at all. Most of the 2xxx and 7xxx alloys have different compositions, different properties, and different applications than the 2524, 2024, or 2024A alloys at issue.

10. I understand that Pechiney proposed to modify its request to seek documents regarding a subset of the 2xxx and 7xxx alloys, as well as certain 6xxx and 8xxx alloys, (including at least the 2x14, 2x18, 2x19, 2x24, 2034, 2048,

2080, 2090, 2091, 6013, 6061, 7010, 7039, 7049, 7x50, 7055, 7x75, 8090, and 8091 alloys) on the ground that all of these alloys are directly relevant "to the claimed novelty of the '639 patent". In my view, as an inventor of the '639 patent and a metallurgist, that position is not correct. Most of these alloys are substantially different from the products disclosed in the '639 patent in terms of composition, damage tolerance properties, and/or applications.

11. Unlike the copper-based 2x24 alloys, the 6013 and 6061 alloys are magnesium-silicon based, the 7xxx alloys are zinc-based, and the 8090 and 8091 alloys are lithium based. The 7039 alloy, for example, contains no copper, is not known for its toughness properties, and has nothing to do with aerospace. In fact, the 7039 alloy is used for armor plate. To my knowledge, of the listed 7xxx alloys, 7475 sheet is only rarely used in commercial fuselage sheet applications and the other 7xxx alloys are not used at all for such applications.

12. It is my understanding that Pechiney has now proposed to withdraw its requests for documents regarding 6xxx, 7xxx, and 8xxx alloys, provided Alcoa produce certain information regarding the 2x14, 2x18, 2x19, 2x24, 2034, 2048, 2080, 2090, and 2091 alloys.

13. I understand that we have offered to produce documents regarding the alloys in the 2x24 family, except for the 2424 alloy. To my knowledge, the 2424 alloy was

developed by Kaiser Aluminum Corporation after the application for the '639 patent, and therefore was not prior to our development of the inventions disclosed in the patent. I also understand that we have offered to produce documents that may exist regarding alloys that were developed from programs to improve the damage tolerance properties of the 2024 alloy. In addition to the 2524 and 2024A alloys, that includes the 2048 alloy.

14. The remainder of the 2xxx alloys on Pechiney's revised list, however, do not appear to be even remotely relevant to the inventions of the '639 patent. Not one of the 2014, 2018, 2218, 2618, 2618A, 2219, 2319, 2419, or 2519 alloys is within the 2x24 family, or was developed out a program to improve the damage tolerance properties of 2024, or is even known for high damage tolerance properties.

Scope of Pechiney's Latest Request for Production

15. I understand that, regarding the alloys listed in paragraph 12 above, Pechiney's requests are extremely broad and seek **all** documents regarding the alloys that relate, for example, to damage tolerance. I also understand that Alcoa has proposed to produce documents that may exist relating to each of the 2xxx alloys on Pechiney's revised list in **specific** categories. Those categories (which are subject to a cut-off date of the CIP application date for the '639 patent) include: (1) the development of the alloys; (2) testing methods and results regarding fracture toughness

and/or fatigue crack growth; (3) internal production process specifications; (4) fact sheets (which summarize the composition and properties of the alloys); (5) green letters (10-50 page documents which give an extensive description of the composition and properties of the alloys, and which Alcoa provides to its customers on a confidential basis); and (6) qualifications or specifications provided to aircraft manufacturers. In my view, those documents will provide whatever information can reasonably be located at Alcoa regarding the composition, properties, testing, and process of production of those alloys for the relevant time period.

16. I understand that Pechiney has not accepted that offer but insists on the production (or the identification of every file folder that may contain responsive documents) of a much broader set of information, including all marketing documents, testing documents, or documents reflecting communications with third parties that relate in any way to the damage tolerance attributes of the alloys. I do not believe that these documents will add any meaningful information regarding composition, properties, or production process to the information which we already have proposed to produce. Moreover, it would be both disruptive of the daily operations of the Davenport Works and extremely burdensome for us to produce or identify all files that may contain such documents relating to the twenty alloys on Pechiney's

list. The process of searching for responsive documents regarding the 2524 alloy at the Davenport Works took several weeks: if that search is now extended to twenty different alloys, the search would likely take several months. In addition, a production that is not limited to precise categories of documents (as we have proposed) risks the unnecessary and improper disclosure of proprietary information to one of Alcoa's most significant competitors in aerospace.

I declare under penalty of perjury that the foregoing is true and correct.

Robert W. Westerlund

Robert W. Westerlund

Executed on August 30, 1999

Exhibit 13

62

IN THE UNITED STATES DISTRICT COURT

IN AND FOR THE DISTRICT OF DELAWARE

- - -

PECHINEY RHENALU, : Civil Action

Plaintiff, :

v. :

ALCOA, INC., :

Defendant. : No. 99-301 (SLR)

- - -

Wilmington, Delaware
Thursday, September 2, 1999
9:30 a.m.
Telephone Conference

- - -

BEFORE: HONORABLE SUE L. ROBINSON, U.S.D.C.J.

APPEARANCES:

JOANNE CEBALLOS, ESQ.
Potter Anderson & Corroon LLP
-and-
CHRISTOPHER N. SIPES, ESQ., and
WILLIAM D. IVERSON, ESQ.
Covington & Burling
(Washington, D.C.)

Counsel for Plaintiff

FREDERICK L. COTTRELL, ESQ.
Richards, Layton & Finger
-and-
DANIEL SLIFKIN, ESQ., and
PHILIPPE Z. SELENDY, ESQ.
Cravath, Swaine & Moore
(New York, NY)

Counsel for Defendant

THE COURT: This is Judge Robinson.

(Counsel respond "Good morning.")

THE COURT: I know that Pat took a roll call. I don't need you to repeat that. As always, you need to identify yourself each time you speak in order that we have a clear record.

I have reviewed the letters you sent over. Rather than just identifying issues, both parties basically argued their issues. I don't think I need to hear much more from you. What I want you to do -- and I have got half an hour to give you, so 15 minutes at most per party -- is to respond to the comments made by the opposing party. Particularly, I need Alcoa to respond to the contentions by plaintiff that the prior art alloys and processes, the documents relating to those prior art alloys and processes are relevant because Alcoa's '394 patent, I assume what plaintiff is saying, is prior art and because of this European Patent Office decision and the documents and materials mentioned in that.

With respect to plaintiff, I need you to specifically answer this question for me: That is, when we are talking about post-filing technical developments, it has never been my understanding that, once you have patented something and have a product, that you can't improve it, and it has never been my understanding that enablement means the

best product you could possibly come up with, even though that means years of further development, just that it is the best you could do at the time.

So in my mind, the argument made by plaintiff is not particularly compelling. That's my specific concern with respect to plaintiff's letter.

So I think because it is plaintiff's, basically, request to compel, and we got a three-page letter plus multiple exhibits from them, that I will let Alcoa go first in response to this letter, 15 minutes, and then we will go to plaintiff's counsel to basically have the last word and to respond to anything written by Alcoa's counsel in their letter.

MR. SLIFKIN: Daniel Slifkin of the Cravath firm for Alcoa.

I will turn first to the point Your Honor specifically mentioned you would like a response on.

Before I get to that, I would like to say, to a great extent, the specific examples given in counsel's letter are in fact not in dispute. For example, the discussion of the 2124 alloy, there is no dispute there. Alcoa is in fact producing documents relating to the 2124.

Similarly, the document referred to by the European Patent Office, which was a report by somebody at Boeing, has in fact been produced and was produced to

Pechiney by Alcoa approximately one month ago. Again, the testing documents, the 2524, we have in fact produced those and are completing that production shortly. Similarly, we are producing the general test procedures documents that they asked for.

So the dispute is not so much about the specific example that plaintiff has identified in its letter, but about the other documents that we would have to produce if an order were entered requiring us to comply with the literal terms of their request, which would require a great deal of commercially sensitive material to be produced, which we believe is not relevant to this dispute, to one of our key competitors in the aerospace alloy area.

If I could turn first to the issue of what prior art alloys are relevant here. I mentioned producing 2124. I mentioned the document referring to the European Patent Office has in fact already been produced.

Let me turn to the '394 patent. Now, the dispute is about the '639 patent. And the '639 patent is about one particular alloy. It is about an improvement to the 2024 alloy, which is one type of copper-based alloy. As Your Honor will be aware, the 2000 series of alloys are copper-based. It is how you take that 2024 alloy, which has been used for 50 years for aircraft fuselages, and improve it by changing its compositional limits and by certain process

steps to come up with a better alloy for making planes for 2524.

Now, so we are clear, Alcoa is in fact producing, within the categories -- and I will come to which type of documents -- within the categories identified in the letter to the Court, all the documents concerning the 2X24 series of alloys the plaintiffs requested, and also those other two series alloys which were designed to improve upon 2024. Specifically, the 2048 alloys.

What we don't want to produce is the other two series copper-based alloys which we don't regard as relevant and the 7 series alloys, which is based on zinc, the 6 series alloys, alloys based on magnesium silicon, or the 8 series alloys, based on lithium, that are called for by plaintiff's request.

Those alloys, these other two series, the 6, 7 and 8 series alloys, are referenced in the '394 patent. But our position is the '394 patent is simply a different patent which contains a different invention. It is not designed to improve upon 2024. It is not designed for aircraft fuselage production. It has different compositional limits than the '639 patent.

And, with respect, counsel's letter, to the extent that it is addressed that the process in the '394 patent is essentially the same as the '639, that is simply

not correct. It is a different mechanical treatment. If '639 were the same as '394, there would be no need for Alcoa to have gotten a new patent and we wouldn't be having this dispute about '639. We would be talking about '394.

Although I am not a technical expert, I am told by Mr. Westerlund, who put in a declaration on this point, that the chemical process in the '639 patent is completely different to that in '394. The title for the '394 patent is about how to prevent re-crystallization of the aluminum during the working process, to improve certain properties. The '639 patent, and this is in Column 3 of the '639 patent, it specifically allows re-crystallization rather than prevents it and is designed to control that to achieve other properties in other types of material. With that, that is all confirmed by Mr. Westerlund's affidavit.

So, for example, whereas the earlier patent refers to the 7,000 series of alloys, those aren't referred to at all in the patent in dispute.

For example, the 7039 alloy, that is not based on copper. It is based on zinc. So it falls outside the compositional limits of the patent in dispute. It is not damage-tolerant, which is the key improvement that Alcoa achieved in the '639 patent. It is not used in aerospace, which is what the '639 patent is used for. In fact, it is used for armor plate. So in our view, that patent can't be

relevant.

In fact, the fact that it's referred to in the '394 patent demonstrates why '394 isn't relevant, because it concerns these other alloys with different properties used in different applications. I could continue. The 2X18 --

THE COURT: Except you don't have unlimited time. I think you have made your point. If you have other issues, I think you probably would be best served by going on.

MR. SLIFKIN: Yes, ma'am.

If we could turn to the scope, there is another issue, which is the scope of the prior art production. Let's say we have decided that a certain alloy is relevant prior art. Then the question is what we should produce. We have very broad requests. In particular, we have requests that ask for all our production documents and all our marketing documents for the supposed prior art.

We are proposing to give documents showing composition properties, testing and production process. And that is listed in Footnote 2 to our letter to the Court. It is our view that to do anything more would be hugely burdensome, would be extremely intrusive into Alcoa's business, is not relevant. It is simply irrelevant how we went about selling prior art as to whether or not it is in fact prior art. And there is no issue with respect to the

marketing of these other alloys, just 2524.

And would take a huge amount of time and money and give important commercial information to our competitor. And, frankly, we offered -- the research would take months, as referenced in the Harrington declaration. We in fact have offered to make an initial production, to have Pechiney look at that, and to then come back and tell us what more they need. They refused that offer, insisting that we provide some index of the documents we are not producing, which, frankly, would be so burdensome, it would be easier just to produce them. Again, that would take months.

I would just like to briefly reference the testing documents.

As I said earlier, we are giving all testing documents concerning 2524 irrespective of date. And we are also producing all general testing documents, that is to say, our practices, our procedures, our studies, the materials that are referenced in counsel's letter, we are actually producing.

What we don't want to produce is, because these are standardized tests, is every time that we run this test on any of the requested materials, to have to produce that test data. And the series of alloys that are requested by plaintiff with respect to these testing materials are over 110 different alloys. We would have to search through each

of these tests, each test ever performed on any of those 110 alloys and produce it, even though those aren't the alloys in dispute, because that request is not limited to the exhibit.

Finally, if I could just mention the last request that Pechiney makes in its letter for patent submissions, et cetera. We are providing all submissions to Patent Offices both in the U.S. and abroad with respect to the '639 patent and its foreign counterparts. But the requests as drafted, for example, Request No. 26, goes far beyond that. This is attached as Exhibit A to Pechiney's letter.

Request No. 26 asks for all documents relating to any submission to any patent granting authority anywhere in the world relating to any aluminum alloys by a list of people. One, for example, is a man called Jim Staley, the very noted scientist, now retired from Alcoa, has dozens of patents issued to him, is not an inventor of the '693 patent.

The request would require us to go and get every document relating to every submission he ever made to a Patent Office, from January 1st, 1960, on any aluminum alloy, even though none of those alloys are actually in dispute here.

If Your Honor would like to hear us on post-patent developments, I would be pleased to address that. The one point we haven't been able to address is the Bruning case, which is cited by plaintiff's counsel. We took

a look at that case last night. Our reading is as follows. In Bruning, there was a test done to see if you give the patent to a scientist, the scientist can essentially come up with the claimed invention, it is enabled.

That is not what is being sought here. They are asking for the specifications, which include post-development production processes on an alloy product. In fact, we are giving all of the testing data on 2524.

What we don't want to give are our trade secrets about how we improve this product after it was patented, how we commercially implement it, how we achieve certain properties that have nothing to do with the properties identified in the patent, because what we have done, at great expense to Alcoa, is commercially extremely sensitive and has no relevance to the issues in dispute in this action.

Thank you, Your Honor.

THE COURT: Thank you. Let's hear from plaintiff's counsel.

MR. SIPES: Chris Sipes from Covington & Burling.

Let me first address what you asked me to address, the post-filing developments.

What we are talking about here is Alcoa's commercial embodiment of their patent. We believe it is relevant for two reasons. First, they have not disclaimed

the intent to rely on the commercial success of the patented product in showing nonobviousness or claiming nonobviousness of their patents.

Now, there has been agreement on both sides that that product that they market is not what is described in the patent, that they did additional development work in order to market.

The question, therefore, of the degree to which this product reflects the invention they claim there is an open question.

In addition to that, Pechiney has pled nonenablement. These patent claims are very broad, and we believe, Your Honor, that based on the teachings of the patent, you cannot make the full scope of the claims that they are claiming. This, Your Honor, we believe, is reflected in the fact that they have had to do additional work to market their product, and in fact, product they have been unable to market. But they are not providing us with the documents that have shown the testing and development work they have done since March of 1992.

As to the Bruning case, that demonstrates -- it is a recent Federal Circuit case -- events that occur after filing, after the application is filed, are relevant to the enablement decision. The documents we seek either will directly bear on that or lead to information that does. As

it is now, they would cut Pechiney off from knowing anything that was done to the product after March of 1992.

And, Your Honor, there is a protective order in place here to preserve commercial sensitivity. That protective order prevents any non-lawyer from seeing these documents. And the in-house lawyers who are were included at Alcoa's insistence. We have been willing to agree to a protective order that had a category of documents that would be restricted to outside counsel. They insisted that in-house counsel see it. And that is the full scope of people who will see it.

Turning just for a minute to the issues about prior art that they discussed, the deadline for production of documents was yesterday. We have not received documents regarding the 2124, such as the technical letters, one of which we have had here, or related information. The primary problem we are having is that Alcoa keeps referring to categories of documents that they will produce, and these categories they, themselves define.

It is impossible for us to tell what is and is not going to be produced under their sort of ill-defined categories. We made requests for documents, requests that we can know what will be produced. We have offered to try to do carveouts to them. But we need to have responses to our requests. We cannot rely on their categories. The fact that

so many of these documents were not produced to us confirms for us the fact that we have no idea of what it is they will or will not produce under their, quote, categories.

THE COURT: Mr. Sipes, before you go on, let me make sure I understand that statement. Instead of saying these are the documents that are responsive to Request No. 12, they are just giving you documents that they have characterized in whatever fashion they want to, and so it is difficult for you to tell whether they are responsive?

MR. SIPES: Exactly right, Your Honor. It's impossible for us to know what will or will not be produced based on their categories.

THE COURT: All right. Thank you.

MR. SIPES: That is particularly critical here, Your Honor. As you know, Alcoa is the largest producer of these aluminum products in the United States. Of course, under the patent laws, the focus of prior art is the aluminum that was in use or on sale or known in the United States.

So we are dealing with a case here where a lot of the important prior art resides within the files of Alcoa. This is not a fishing expedition. There is good reason to believe that this patent is invalid. In fact, the European Patent Office, relying on a Boeing publication, has found it to be invalid, provisionally.

And the question here is the ability, then, to

get the relevant documents about prior art to confirm -- to prove invalidity in our case, which in fact Pechiney has the burden here to prove anticipation or obviousness. And those are the documents that we need to know what we are getting. We need those documents.

Now, the treatment of Cho is a perfect example, the '394 patent. This is a patent which shows the same process as what the '639 patent claims, intermediate reheating being done to a wide variety of alloys, specifically to improve the damage tolerance of those alloys. It is an Alcoa patent. It was filed in 1988. It's clear that the process is old to achieve the same results, improved damage tolerance, and that many of these alloys, it was known, it was marketed. And the facts of all this work, of course, reside within Alcoa's files.

Now, I hear Mr. Slifkin saying that in his view he doesn't view the patent as relevant. But, of course, we have the burden to prove here. The patent uses the same process for the same reason, to improve damage tolerance, in the same way, it is to dissolve intermetallic particles during the processing steps, and it is very relevant, it was not disclosed to the examiner, and it was done -- the process specifically referred to as being applicable to a wide variety of alloys, the alloys we are seeking, including 2024, 2124, all these alloys that even Alcoa acknowledges are

relevant. Those are the -- you know, they can argue it is not relevant. But it is our burden. We need the documents in order to be able to develop our case.

Finally, they make reference to the burden. First off, Your Honor, you should know that to date -- and the final date for production was September 1 -- Alcoa has produced around 50,000 pages of documents. Pechiney has produced over 140,000 pages of documents.

To be honest, Your Honor, the production has not at all been burdensome in this case. And their claims of burden are very conclusory. We have offered them, if there are specific carveouts from our request, that they want to describe the files rather than produce documents or search them, to alleviate that, we are willing to take such an approach. They have been unwilling to do it. But their claim of burden here so far is completely unsubstantiated.

THE COURT: All right. Anything further?

MR. SIPES: I think that does it.

MR. SLIFKIN: Would you like a response from Alcoa?

THE COURT: No, I don't think so. You have given me plenty of material. I am not going to make a decision today on the phone, because you did give me a lot of material, and I was in court all yesterday afternoon.

I am going to review the material, and I will

issue a very brief but hopefully understandable written order next week. If I do have any further questions, I will certainly let counsel know. I appreciate your comments.

Are there any other issues not addressed in the letters so far that we can helpfully address in the few minutes remaining?

If not, thank you very much, counsel. Have a good holiday weekend.

(Conference concluded at 9:53 a.m.)

- - -

Reporter: Kevin Maurer

CERTIFICATE OF SERVICE

I hereby certify that on the 15th day of August, 2006, the attached **APPENDIX TO DEFENDANTS' MEMORANDUM OF LAW IN SUPPORT OF THEIR MOTION TO DISMISS FOR FAILURE TO STATE A CLAIM UPON WHICH RELIEF CAN BE GRANTED** was served upon the below-named counsel of record at the address and in the manner indicated:

Frederick L. Cottrell, III, Esquire
Richards, Layton & Finger
One Rodney Square
P.O. Box 551
Wilmington, DE 19899

HAND DELIVERY

Evan R. Chesler, Esquire
Cravath, Swaine & Moore LLP
Worldwide Plaza
825 Eighth Avenue
New York, NY 10019

VIA ELECTRONIC MAIL

William G. Todd, Esquire
Greenberg Traurig, LLP
200 Park Avenue
New York, NY 10166

VIA ELECTRONIC MAIL

/s/ Steven J. Balick

Steven J. Balick

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